Engineering Library

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIV.—No. 2961.] *LONDON: FRIDAY, SEPTEMBER 29, 1922.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 29.

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Steam and Electric Cranes,
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637
LIST OF STANDARD SIZES ON APPLICATION.
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The Strongest Chain IN THE WORLD. 898
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Specification and Workmanship equal to Main Line Locomotives.
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Sole Makers: SPENCER-BONECOURT, LTD., 577
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SHALLOW DRAFT VESSELS. 818

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PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
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See page 17, Sept. 22. 9947

The Mitchell Conveyor and TRANSPORTER CO., LTD., CONTRACTING ENGINEERS.
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Diesel Engines, Six Cylinder,
Two and Four stroke, 850, 1000, 1200 H.P., excellent condition. Dynamos for above 250 or 500 volts, D.C. Immediate delivery and low price.
Two 500 Kw. Parsons Turbine Sets, 250 or 500 volts, D.C., with condensing plant and spare armature. Price £2200.
Electrical driven Centrifugal, Ram and other Pumps from 1½ in.–10 in. outlet.
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MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION, RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 19.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5128

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement Page 26. 9952

Economy!
HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS.
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TODD SHIPYARDS CORPORATION, Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4895

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Makers of
Evaporating and Distilling Plants.
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Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 846

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Traversers.
Transporters.
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YARROW BOILERS. 819

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MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1210
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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Head, Wrightson & Co., LIMITED.
See Advertisement page 63, Sept. 22. 3409

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 762
See Full Page Advt., page 62, Sept. 15.

Crane and Sling Chains up to 4 in. dia. iron, also Electric Welded Chains, Blocks and Crab Winches for chains or ropes, Screw Jacks, Patent two-speed Hydraulic Jacks, Hooks, Swivels, Shackles, General Smiths' Work. Estd. 1841. —FELLOWS BROS., LTD., Cradley Heath, Staffs. 9156

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CHARTERED PATENT AGENTS, 876
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Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See Illus. Advt. last week, page 15. 9764

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69 & 69, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities.

Mechanical Designing, Working Drawings, Coloured Drawings, Card or Wood Models, Schemes, Diagrams & technical work generally.—JOY & HARRISON, Ulster Chambers, 168, Regent St., W.1. 'Phone: Regent 1697. 980

See Advt. Page 132 Sept. 22.
Steam Hammers
Power Hammers
Steam and Friction
Drop Stamps.
B. & S. Massey, Ltd., 9011 MANCHESTER.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 606

APPLICATION FOR A LICENCE OF THE BOARD OF TRADE.

Notice is Hereby Given that

in pursuance of the 20th Section of the Companies (Consolidation) Act, 1908, application has been made to the Board of Trade for a Licence directing an Association about to be formed under the name of "THE INSTITUTION OF ENGINEERING INSPECTION" to be registered with Limited Liability without the addition of the word "Limited" to its name.

The objects for which the Association is proposed to be established are:—

To take over such of the assets and liabilities, if any, of an unincorporated association known as "The Technical Inspection Association" as may lawfully be taken over by the Institution.

The other objects of the Association are set out in extenso in the Memorandum of Association, a copy of which may be inspected at the Office of HERBERT A. KITE, Esq., 2, Dean's Yard, The Sanctuary, Westminster, S.W. 1, Solicitor.

Notice is hereby further given that any person, Company or Corporation objecting to this application may bring such objection before the Board of Trade on or before the 16th day of October next by a letter addressed to the Comptroller of the Companies Department, Board of Trade, Great George Street, London, S.W. 1.

Dated this 20th day of September, 1922.
C. J. WHARTON,
Hon. Secretary. W 353

ENGINEERING AND TECHNICAL OPTICS.

Northampton Polytechnic

INSTITUTE, St. John Street, London, E.C. 1.
ENGINEERING DAY COLLEGE.

Full-Time Day Courses in the Theory and Practice of Civil, Mechanical, and Electrical Engineering. The Courses in Civil and Mechanical Engineering include specialisation in Automobile and Aeronautical Engineering, and those in Electrical Engineering include specialisation in RADIO-TELEGRAPHY.

A SPECIAL ENTRANCH EXAMINATION is held at the end of September before the commencement of each session. The Courses include periods spent in commercial workshops and extend over four years. They also prepare for the Degree of B.Sc. in Engineering at the University of London. Fees £18 or £13 per annum.

THREE ENTRANCE SCHOLARSHIPS of the value of £62 each for the complete course will be offered for competition at the annual entrance examination in September.

OPTICAL ENGINEERING AND TECHNICAL OPTICS.

Full and Part-time Courses in this important department of Applied Science are given in specially equipped laboratories and lecture rooms. The annual entrance examination is held at the end of September.

EVENING TECHNICAL COURSES

in all branches of Mechanical and Electrical Engineering commence on Monday, September 25th, 1922.

The Laboratories, both Mechanical and Electrical, are well equipped with modern apparatus which, on the Mechanical side, provides for specialisation in Automobile and Aeronautical Engineering, and, on the Electrical side, for specialisation in Alternate and Continuous Current Work, in Radio-Telegraphy and Telephony, and in Electrical Testing.

More complete particulars, together with conditions of entrance, &c., and all information respecting the work of the Institute can be obtained at the Institute or on application to—

R. MULLINEUX WALMSLEY, D.Sc.
Principal.
W 222

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—29, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 884

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Inst. C.E. Exams.—Successes

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Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 748, Offices of ENGINEERING.

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ENGINEERING WORK.

Firms Desirous of Tendering

for SMALL REPETITION WORK in large quantities, can have particulars of same by applying to:—
W. S. MUNDLE, Engineer, Glasshouse Lane, Gateshead-on-Tyne. Fee 15/0 (to cover cost of Drawings), not returnable. W 397

LONDON & NORTH WESTERN RAILWAY COMPANY.

GENERATING PLANT FOR SALE.

The Railway Company invite

Offers for the following:—

ONE "Yates and Thom" CROSS COMPOUND CORLISS HORIZONTAL ENGINE, direct coupled to a 1500 Kw. "Dick Kerr" Generator.

The Set is suitable for a steam pressure of 160 lbs. per sq. in., and generates A.C. 3-phase, 7500 volts, 25-cycles current when running at 75 revs. per min. High-pressure cylinders 32 in. dia. by 4 ft. 6 in. stroke, and low-pressure cylinders 64 in. dia. by 4 ft. 6 in. stroke, and Indicated Horse Power 2310.

The Set is fitted in the centre of the crank shaft with a large fly wheel alternator, so that it is possible for the engine to be converted for rope driving.

The Set, which is complete with Jet Condensing Plant, Air Pump, and spare parts, etc., is at present in working condition and may be seen running during the next few weeks at Formby Power Station, on the Liverpool and Southport Line. The total weight of this Set is in the neighbourhood of 295 tons.

This Set can be inspected on site, and any further information can be obtained, on application to GEO. HUGHES, Chief Mechanical & Electrical Engineer, L. & N.W. Railway Works, HORWICH, S.O., Lancashire. W 352

NOTTINGHAM CORPORATION.

NORTH WILFORD POWER STATION.

The Nottingham Corporation invite

Tenders for the Manufacture,

DELIVERY and ERECTION of the undermentioned ENGINEERING WORKS in connection with the above Station, viz:—

SECTION "C." Two 650 K.V.A. Three-phase Static Transformers.
Two 900 K.V.A. Six-phase Static Transformers.
One 150 K.V.A. Single-phase Static Transformer.

SECTION "G." Three Steam Turbine-driven Boiler Feed Pumps, each for 25,000 gallons per hour, with three exhaust steam heating nozzles

SECTION "L." Four Gravity Bucket Coal Conveyers with crushers, etc.

SECTION "M." Accumulators, etc.

Specifications, General Conditions and forms of Tender may be obtained from Messrs. PREECE, CARDEW & RIDER, 8, Queen Annes Gate, Westminster, S.W. 1, on payment of a deposit of £5 for each Section, which will be refunded on receipt of a bona-fide Tender within the prescribed time.

Extra copies of the Specifications may be obtained on payment of Ten Shillings for each copy, which will not be returnable.

Sealed Tenders, endorsed "Electricity Department, Tender for ....." must be delivered to me at my Office before Ten a.m. on Friday, 27th October, 1922.

The lowest or any Tender will not necessarily be accepted, and the Corporation will not consider any Tender which is incomplete, or which does not include the whole of the work covered by the Specification for one or other of the Sections.

By Order,
W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
23rd September, 1922. W 399

STATE ELECTRICITY COMMISSION OF VICTORIA.
TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available on and after 21st September, 1922, upon application to:—

AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London, W.C. 2.

SPECIFICATION No. 308—BACK PRESSURE STEAM TURBINE INCLUDING ONE 1500 KW. TURBO ALTERNATOR WITH EXHAUST VALVES, EXHAUST PRESSURE REGULATOR, CONTROLLING STEAM ADMISSION, BYE PASS REDUCING VALVES, ETC., STEAM 250 lbs. per square inch. 6,300 FAR EXHAUST 15 lbs. to 45 lbs., gauge, Alternator 6600 Volts, 3 phase, 50 cycles.

SPECIFICATION No. 317—WATER TUBE BOILERS & ACCESSORIES, INCLUDING

SECTION 1—FOUR BOILERS, 4800 sq. ft., H.S. STEP GRATES, DAMPERS, MOUNTINGS, ETC.

SECTION 2—STRUCTURAL STEELWORK FOR BOILER HOUSE, BUNKERS AND TURBINE HOUSE, INCLUDING FLOOR, FRAMING, STAIRS, ETC.

SECTION 3—TURBINE DRIVEN FEED PUMPS, MAKE-UP PUMPS, COLLECTOR DRUMS, TANKS, METERS, ETC.

SECTION 4—COMPLETE SYSTEM OF PIPING, VALVES, ETC., FOR ALL PLANT.

Both the above Specifications cover the supply, delivery and supervision of erection of complete plant, sections being inseparable.

CHARGE:—£2 2s. for the first two copies of Tender Form, Conditions of Contract, and Specification complete. These charges will be returned on receipt of a bona fide Tender. A third copy and any further copies will be supplied for the sum of £1 1s. each.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is to be lodged with Tender in each instance.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed forms, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m. (in the case of Specification No. 308), 31st January, 1923, and (in the case of Specification No. 317) 15th January, 1923.

E. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. W 395

THE WORCESTER ELECTRICITY DEPARTMENT have

For Disposal Six E. Type

STOKERS by the Underfeed Company, each having a grate area of 64 sq. ft. The Stokers are part of large boiler plant purchased from the Disposal Board and are only offered for sale owing to the heating surface of boilers being increased on re-installation.

Stokers have only had about 12 months' service and are in excellent condition.

The highest or any Tender may not necessarily be accepted.

Offers to be sent to:—
C. M. SHAW,
City Electrical Engineer,
Electricity Works,
Worcester. W 387

AUCKLAND HARBOUR BOARD,
NEW ZEALAND.

Tenders are Invited for the

SUPPLY and DELIVERY of
TWELVE (12) Five-ton
(and alternatively for Three-ton)
SEMI-PORTAL BALANCED-JIB ELECTRIC QUAY CRANES.
FOUR (4) Five-ton (and alternatively for Three-ton) BALANCED-JIB ELECTRIC ROOF CRANES.
SIX (6) One-ton
ELECTRIC MONO-RAIL CRANES.

SPECIFICATIONS, DIAGRAMS, AND FORMS OF TENDER can be obtained at the Office of the Board's Agents:—
Messrs. W. & A. MCARTHUR, LTD.,
18-19, Silk Street,
Cripplegate, London, E.C. 2.,
on payment of a deposit (returnable) of Two Guineas.

Tenders to reach Auckland by Noon, on February 1st, 1923, addressed:—THE CHAIRMAN, Harbour Board, Auckland, New Zealand. W 276

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

	Fee for Specification.
Locomotive Boilers	£1
Superheater Goods and Passenger Engines	£1

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Boilers," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 17th October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 26th September, 1922. W 406

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

No.		Fee for Specification.
1.	Miscellaneous Articles and Materials	10s.
2.	Spare parts of Carriages and Wagons (W.I. Axleguards, &c.)	£1
3.	Brass and Iron or Steel Screws	10s.
4.	Galvanised Wrought Iron Water Tubes, &c.	10s.
5.	Bolts, Nuts, Rivets, &c.	£1
6.	India-rubber Hose Pipes, Sheets, &c.	10s.
7.	Mild Steel Bars, Sections, &c., for Miscellaneous purposes	10s.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Miscellaneous Articles and Materials," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 10th October, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 27th September, 1922. W 423

Tenders are Invited for the

PURCHASE of:—

TWO WOODESON PATENT WATER TUBE BOILERS, superheaters and hand fired furnaces now lying at Thornhill Power Station. Capacity of each boiler 25,000 lb. of water per hour from and at 212° F. At present insured for a working pressure of 200 lb. per square inch. Heating surface 4670 square feet. Complete with Hopkinsons mountings and Superheat Furnace Company's Grates of 96.5 square feet area.

These are in first-class condition and have only been removed to provide space for larger units.

The boilers will be dismantled by the Company but it is desired that they should be loaded and removed by the Purchaser; Also

ONE CONDENSING PLANT, consisting of a Surface Condenser, made by the British Westinghouse Company. Cooling surface 4400 square feet, weight 10.5 tons, now lying at Barugh Power Station, and a
Rees Roturbo CIRCULATING PUMP and
Le Blanc AIR PUMP on one shaft driven by 60 B.H.P. Westinghouse Turbine.

ONE 18 in. bore atmospheric exhaust valve.
ONE 48 in. bore copper expansion joint.

This plant was installed in 1913, is in good condition and has been displaced by a larger unit.

FOR PERMISSION TO VIEW, and further details apply to:—
THE YORKSHIRE ELECTRIC POWER COMPANY,
36, Park Place, W 398
Leeds.

LONDON COUNTY COUNCIL.

TWIN SCREW STEAMSHIP.

The London County Council invites

Tenders for the Construction

and DELIVERY of a TWIN SCREW STEAMSHIP, about 200 ft. long by 43 ft. beam, with machinery, etc., for the conveyance of 1500 tons of sewage sludge from the Outfall Works at Crossness and Barking Creek to the North Sea.

Persons desiring to submit Tenders may obtain, on and after Monday, 2nd October, 1922, the Drawings, Specifications, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £5. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender, and shall not have withdrawn the same. Full particulars of the vessel may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

Tenders must be delivered to the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1. No Tender received after Four p.m. on Monday, 30th October, 1922, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, W 386
Clerk of the London County Council.

APPOINTMENTS OPEN.

NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

ATKINSON ROAD JUNIOR DAY TECHNICAL SCHOOL.

Required in January, 1923, a

TEACHER of TECHNICAL DRAWING (Engineering). Graduate preferred. Burnham Technical Scale.

Form of Application to be obtained by sending stamped addressed foolscap envelope to,
THOS. WALLING,
Director of Education.

Education Offices,
Northumberland Road. W 431

Commercial Man Wanted,

experienced in Shipbuilding and Engineering work, with good connection amongst Shipowners, and competent to negotiate Contracts. Liberal terms to suitable man.—Address "ENGINEERING," WM. PORTEOUS & CO., Advertising Agents, Glasgow. W 310

Representative Wanted in

London for a Boilermaking Firm; capable man likely to secure boiler orders, tanks, and general wrought iron and steel work.—Address, stating experience and terms, W 370, Offices of ENGINEERING.

Wanted by Blast Furnace

Owners in Midlands, GENTLEMAN or FIRM for sale of Pig Iron, Manchester and other districts.—Address, stating experience and salary required, W 395, Offices of ENGINEERING.

Required, Experienced En-

GINEERING REPRESENTATIVE, with commercial and technical ability, in Manchester district for sale of important patent steam saving specialities. Good connection with steam power users, mills and factories essential. Salary and commission.—Address W 378, Offices of ENGINEERING.

Wanted, Traveller already

travelling in Engineers' Small Tools, with extensive experience, to take up some special work.—Address, W 393, Offices of ENGINEERING.

Wanted, First-class Electro-

Plating and Polishing Shop SUPERINTENDENT, must be thorough organiser, well up on the technical side. Man with rule of thumb methods need not apply. Good prospects and permanency.—Address, W 383, Offices of ENGINEERING.

Wanted, a Young Man with

IDEAS.—A large Electrical Company manufacturing accessories for Motor Cars HAS a VACANCY on its staff for a young man who has ideas.

Only men with inventive brains need apply. State age, experience and salary required.—Address, W 423, Offices of ENGINEERING.

Wanted, by Engineering

Firm in India, ASSISTANT to push sales of Colliery requisites, age about 25, single. Only those with expert knowledge of Colliery requirements will be considered.—Reply, giving fullest details of experience, also salary required, to Z. C. 674, care DEACONS, Leadenhall Street, London, E.C. 3. W 402

Leading Draughtsman

WANTED by a firm with world-wide reputation for pumping and hydraulic machinery, large and small. This is a really good opening with immediate prospects of promotion to right man. Must have had shop training and wide experience. Age about 25. State salary required. Replies treated confidentially.—Address, W 424, Offices of ENGINEERING.

Centrifugal Pump Draughts-

MAN WANTED by important firm. Must have had shop experience and good technical training. State experience, age, and salary required.—Address, W 425, Offices of ENGINEERING.

First-class Draughtsman

REQUIRED by old-established Crane Firm in the North of England. One experienced in the design of steam and electric cranes. State age, experience and salary. Replies treated confidentially.—Address, W 392, Offices of ENGINEERING.

Draughtsman Required at

once for Steel Works Plant. Must have knowledge of structural and mechanical engineering, surveying, etc. No others need apply. State age, salary, experience, and when at liberty.—Address, W 345, Offices of ENGINEERING.

THE CANADIAN PACIFIC LINER "EMPRESS OF CANADA."

(*Concluded from page* 320.)

THE MAIN TURBINES.

HAVING previously dealt with the general arrangement of the machinery, we now propose to describe the installation in greater detail with the aid of the illustrations given on Plates XXVIII to XXXI and on pages 387 and 388. There are two sets of turbines of the Brown-Curtis type, driving twin screws through double-helical, double-reduction gearing. The ahead portion of each set comprises four separate turbines through which the steam passes in series, the high-pressure and low-pressure turbines being mechanically coupled in tandem and driving one pinion on the outboard side of each gear, while the first intermediate pressure and second intermediate pressure turbines are similarly arranged on the inboard side. Astern turbines, capable of developing about two-thirds of the full ahead power, are placed aft of the ahead turbines, the high pressure portions being incorporated in the second intermediate pressure ahead casings and the low-pressure portions in the low-pressure ahead casings. The longitudinal sections through the turbines given in Figs. 43 and 44 on Plate XXVIII will make the arrangement clear.

On account of the large aggregate horse-power of the turbines, their subdivision into a number of separate units gives a more satisfactory design of the low-pressure turbines than would be possible with the more usual arrangement of two or three turbine units. The rotor, for instance, can be of smaller dimensions, and a better margin of safety as regards critical speeds can be obtained. A further improvement has been effected by making the low-pressure turbines of the double-flow type (see Fig. 43), this arrangement greatly facilitating the flow of the exhaust steam to the condenser and at the same time giving a more compact design in which the end thrust is balanced. It should also be noted that the location of the high-pressure astern unit at the exhaust end of the second intermediate pressure turbine (Fig. 44) ensures the minimum leakage of steam when running ahead owing to the small drop of pressure across the diaphragm between these turbines. The general arrangement has the advantage of distributing the power almost equally to the gearing at all speeds for both ahead and astern running, each pinion transmitting about 6,100 s.h.p. at about 2,000 r.p.m. when running full-speed ahead.

Steam is admitted to each high-pressure turbine through 37 nozzles, of which 19 are on the lower half of the turbine, and are not controlled. The remaining nozzles are arranged in small groups of 4 and 5, each group being controlled by a separate stop valve mounted on the forward end of the casing and operated directly from the starting platform. By means of these valves, the full control pressure can be maintained over a range of powers increasing by small increments from about half to full power, thus giving the minimum of steam consumption throughout the whole range. Overload powers in excess of this can be obtained, if required, by admitting additional steam direct to the first intermediate pressure turbines, a by-pass valve being provided on each control-chest for the purpose. The first stage wheel of each high-pressure turbine is of the velocity-compounded type, with two rows of moving blades. All the other ahead wheels form simple impulse stages, 7 being included in each high-pressure turbine, 9 in the first intermediate pressure turbine, 6 in the second intermediate pressure turbine, and 5 in the low-pressure turbine. The last-mentioned are in duplicate, since the low-pressure turbine is of the two-flow type, so that the total number of rows of moving blades per set is 34. The astern turbines comprise three velocity-compounded stages, the high-pressure portion (Fig. 44) consisting of a three-row wheel followed by a two-row wheel, and the low-pressure portion (Fig. 43) of a single three-row wheel.

The turbine casings are of cast iron throughout. They are of strong construction designed to resist distortion due to temperature changes, and, in the case of each low-pressure turbine, to carry the weight of the suspended condenser. The nozzle plates at the inlets to the various turbines, and the diaphragms between the stages, are of cast iron, with nickel steel blades embedded in the castings. Ready access to the rotors, packings and blades, for inspection or overhaul, has been ensured by making all the diaphragms of the split type, arranged so that their upper halves are retained within the turbine covers when the latter are lifted. The rotors for the high pressure and first intermediate pressure turbines have been machined from solid steel forgings, while those for the second intermediate pressure and low-pressure turbines, and for both astern turbines, are built up of forged steel discs forced on and keyed to forged steel spindles. Rotor blades of phosphor bronze, shrouded at the tips, have been used throughout; they are of the Brown-Curtis combined type, with the blade portions integral with the packing and were machined from the solid section. Steam-packed glands of the carbon-ring type are fitted to each turbine, and the inter-stage diaphragms are packed with serrated rings of phosphor bronze, the diaphragm between the second intermediate-pressure ahead turbine and the high-pressure astern turbine being further provided with a labyrinth packing of special design. These features are all shown in the longitudinal sections, Figs. 43 and 44 on Plate XXVIII. The turbine adjusting blocks are of the Michell type, with double-sided collar for ahead and astern running, and their position aft of the turbines and adjoining the flexible couplings reduces to a minimum the end movement required to be taken up by the latter.

To prevent overspeeding in case the propellers should race in heavy weather, an Aspinall governor of the latest pattern is fitted at the forward end of the turbines. These governors begin to operate at 5 per cent. above the normal full power revolutions, and, at about 15 per cent. above normal speed, the steam is entirely shut off at the bulkhead stop valves. An emergency hand cut-out gear is also provided, and since the governors work through an oil-pressure relay from the main lubricating system, they also come into action in the event of a predetermined reduction in the pressure of the oil supply to the bearings or sprayers. To give aural and visual warning to the engineers that the oil pressure has fallen to near the cutting-out pressure, an oil alarum is fitted which, when in action, works a buzzer and causes a red lamp on the starting platform to light up.

Figs. 45 and 46 on Plate XXIX are reproduced from photographs of the starboard set of turbines and gearing taken during the course of erection in the Fairfield Company's shops. In Fig. 45 the gear case cover has been removed so that the wheels and pinions are visible, but it will be noticed that the first reduction pinions are not in position. The turbines in the foreground are the first and second intermediate pressure units, and the large lagged pipe at the top of the illustration conducts the exhaust from the second intermediate pressure turbine to the low-pressure turbine on the outboard shaft. Fig. 46 illustrates the work at a later stage when the reduction gear had been completed, and also clearly shows the motor-driven turning gear. Similar views taken from the opposite side of the set showing the high-pressure and low-pressure turbines, together with the condenser, are reproduced in Figs. 47 and 48 on Plate XXX; the control valves mounted on the forward end of the high-pressure turbine casing, as above mentioned, are clearly shown in Fig. 48. The starting platform, which is situated at the forward end of the engine-room, is illustrated in Fig. 49 on Plate XXXI. The telegraphs can be seen on the extreme right and left of this illustration, and close to them the port and starboard ahead and astern manœuvring wheels should be noted. The tachometers and revolution counters are mounted on the bulkhead in the centre line of the ship with the various pressure gauges above them, and on each side, as shown, the whole forming a compact and convenient arrangement. It may here be mentioned that an electric lift from the starting platform up to "C" deck, where the engineers' quarters are situated, and also up to the boat deck, is provided. Fig. 50 is a view looking aft from the starting platform and showing the forward ends of the first intermediate pressure turbines of both the port and starboard sets. The ladder shown in the background of this illustration leads up to the flat on which the electric generators are placed, and the hatchway near the foot of the ladder leads down to a lower level at the after end of the engine room where the forced lubrication pumps, &c., are situated.

The main condensers are placed athwartships, one being suspended immediately beneath each low-pressure turbine, as is most clearly shown in Figs. 47 and 48 on Plate XXX. They are of the two-flow type, with sufficient cooling surface to maintain a vacuum of 28 in. of mercury with circulating water at 60° F. The condensers are built up of steel plates, with cast iron doors and waterways, and are fitted with brass tubes and tube plates. It should, perhaps, be explained that the handwheels shown on the condenser covers in Figs. 47 and 48 are for operating a by-pass valve in the water space to enable the bilge injection to be discharged directly overboard, as is required by the latest Board of Trade rules. Two circulating pumps are provided for each condenser, and each can supply three-fourths of the water required to maintain the designed vacuum in one condenser at full ahead power under service conditions. In cold weather, or at reduced power, only one pump is required for each condenser, the other serving as a stand-by. To reduce corrosion of the tubes, the Cumberland electrolytic system has been fitted, and in designing the condensers particular care was taken to keep the velocity of the water through the tubes as low as was compatible with high efficiency.

THE REDUCTION GEARING AND THRUST BLOCKS.

The double reduction gearing, drawings of which are reproduced in Figs. 51 to 54 on page 387, is necessarily of large dimensions and of massive construction, but a compact design of gear case has been secured by running the intermediate wheels in the central gap of the main gear wheels, as shown in Fig. 52, while, as a result of the even distribution of power between the turbine pinions, already referred to, the whole arrangement is particularly well balanced. The gear ratio is such that with the turbines running at 1,970 r.p.m., the speed of rotation of the intermediate wheels and pinions would be 430 r.p.m. and that of the propeller shaft 111 r.p.m. The teeth are of Parsons' standard form, of the same pitch for both steps of the reduction, and the materials employed are nickel steel for the pinion teeth and forged steel for those on the wheels. The turbine pinions have been machined from solid ingots of nickel steel, while the intermediate pinions are formed of sleeves of the same material mounted on forged steel spindles. These spindles also carry the intermediate wheels, built up of cast steel centres with forged steel rims in which the teeth are cut. The main gear wheels have cast iron centres, but are otherwise of similar construction.

A noteworthy feature of the reduction gearing is the application of the principle of the nodal drive, devised by Dr. J. H. Smith, of Belfast, in order to avoid critical speed effects due to torsional vibrations of the various shafts. It will be observed from Fig. 54 that the turbines are connected to their respective pinions by means of long flexible spindles passing through the bore of the pinions and coupled to the latter at their after ends. In this way the natural frequency of torsional vibrations of the turbine rotor shafts has been reduced to a low value, which will not cause synchronism at any speed within the working range. This system, we may mention, was fully described by Dr. Smith in a paper read at the Spring meeting of the Institution of Naval Architects this year, and reproduced, together with the discussion on it, on pages 438, 445 and 467, of our last volume. In connection with the application of the system to the Empress of Canada we should explain, however, that the photographs of the turbines and gearing reproduced in Figs. 45 to 48 on Plates XXIX and XXX were taken before it had been decided to adopt the nodal drive, and that certain modifications had subsequently to be made, mainly in connection with the turning gear. As originally designed, the turning motor was placed directly in line with the first reduction pinion, as shown in Fig. 46, Plate XXIX, and the extension of the spindle required for the nodal drive necessitated its removal to another position.

The gear cases are of cast iron, and of massive

construction. All the bearings, together with the turbine bearings, are lubricated under pressure, while the gears themselves are sprayed with a continuous supply of specially cooled oil. The oil-supply pipes to the sprayers, we may mention, are each fitted with indicators in the form of a small rotating vane enclosed in an inverted glass cup, the rotation of the vane showing that the oil is flowing. The bottom of each gear case forms a sump from which the spent oil is drained to a tank formed in the structure of the double bottom, whence it is pumped through filters and coolers, returning finally to the forced lubrication supply mains. For turning the turbines and gearing, a connection is made through the inboard intermediate gear spindle at the aft end through worm and chain gearing to a 25 b.h.p. motor. The main shaft can be revolved once in about 10 minutes by this means. Lifting blocks and tackle have been arranged so that the turbines and gearing can be overhauled and examined with the minimum of labour, and as only unskilled labour will be available when the ship is at her station, the whole of the lifting arrangements have been made exceptionally complete. Means have been devised for taking the main wheels out of the ship, if occasion for this should arise, the dummy funnel being removed, with all its internal fittings intact, for the purpose.

To take the propeller thrust a block of the Michell type is fitted immediately aft of each of the reduction-gears as shown in the general arrangement plan, Fig. 33 on Plate XXVI, accompanying our issue of September 15. Detailed drawings of one of the thrust blocks are reproduced in Figs. 55 to 59 on page 387 of this issue, and from these it will be noticed that the bearing pads are mounted on a spherically-seated ring in order to equalise the loads on all the pads. Other details of the design can be followed by a careful examination of the illustrations. Each of the propellers, which are 19 ft. in diameter and are outboard turning, has four manganese bronze blades fitted to a cast steel boss, and a long sheet-brass cone, filled with paraffin wax, is attached to the boss in order to reduce eddying. The propellers, it may be added, have sufficient immersion to reduce to a minimum the tendency to race in a heavy sea.

Engine Room and Ship Auxiliaries.

Of the more important auxiliaries, we may mention that the main air pumps, of which there are two, are of Messrs. G. and J. Weir's Dual type, each having one wet and one dry cylinder 33 in. in diameter by 18 in. stroke, the steam cylinder being 18 in. in diameter. These pumps, as is best shown in Fig. 33 on Plate XXVI, published with our issue of September 15, are placed at the forward end of the turbines conveniently for discharging into two hotwell pumps at the forward bulkhead. The hotwell pumps are also of Messrs. Weir's make and each has a steam cylinder 9 in. in diameter, a pump cylinder 11 in. in diameter, with a stroke of 24 in. These discharge through a Uniflux surface heater, having 450 sq. ft. of heating surface, in which the auxiliary exhaust from the main range is used to heat the feed to about 155° F. The feed is also passed through a Weir contact heater in which it is mixed with the clean exhaust from the turbo-generators and thereby raised in temperature to 220° F. Any excess of clean exhaust can be led to the second intermediate pressure turbines for the purpose of doing further work. In order to utilise as much as possible of the heat in the various exhaust systems, the drains from the ship's heating system, and from the galley and pantry appliances, can be led into the hotwell when desired. To deal with these ship-service drains, a separate drain condenser, with combined air and circulating pump by Messrs. Dawson and Downie, has also been fitted.

After leaving the direct-contact heater, which is mounted high up in the engine-room hatch as shown in Fig. 30 on Plate XXVI *ante*, the feed water is dealt with by the main-feed pumps of which there are four; two of these are, however, of sufficient capacity for full-power requirements. The feed pumps are of Weir's manufacture and have steam cylinders 18½ in. in diameter, and pump cylinders 13 in. in diameter, with a stroke of 27 in. Feed filters, of Messrs. Carruther's make, are placed between the air pumps and the hotwell pumps, and are fitted in duplicate so that one can be cleaned while the other is in use.

Forced lubrication is supplied to all turbine and gear bearings, of which there are over 50, and also to the tunnel blocks. For this service four Weir pumps with steam cylinders 9 in. in diameter and pump cylinders 11 in. in diameter by 21 in. stroke, are employed. They are placed, as shown in Figs. 31 and 33 on Plate XXVI *ante*, at the after-end of the engine room, but are visible from the starting platform. Two of the pumps are used for the bearing oil, which is passed through two oil coolers in parallel, and one for supplying the sprayers for the gearing. Under normal conditions, the last-mentioned pump draws its supply from the discharge from the bearing pumps and discharges the oil through a third cooler, thus increasing the viscosity of the oil for the sprayers—a feature which makes for quieter running. The fourth pump is used as a stand-by for both bearing and sprayer systems.

The other engine-room auxiliaries, all of which are shown on the drawings reproduced on Plate XXVI *ante*, include four Paul main circulating pumps; a Lamont duplex water-service pump; general service, fresh water, ballast, bilge and sanitary pumps by Carruthers; two Drysdale motor-driven sanitary pumps; two Weir's evaporators with a capacity of 75 tons each; and two Weir's distillers, each having 151·6 sq. ft. of condensing surface.

The refrigerating machinery, which is placed in the shaft tunnel, consists of two single CO_2 machines of the horizontal marine type, by Messrs. J. and E. Hall. The two evaporators and a brine-return tank are placed in an insulated room in which spare CO_2 flasks are also carried. For circulating sea water through the CO_2 condensers, two vertical duplex steam pumps are employed and three pumps of the same type are used for circulating the cold brine. A separate tank is also provided for mixing brine, and an ice-making tank is fitted in the ship's provision chambers.

The Electrical Installation.

The electrical installation of the vessel is of a very complete character, and the main generating plant includes three 275 kw. turbo generators by Messrs. W. H. Allen, Son and Co., Limited. These are mounted on a flat at the after-end of the engine room, as shown in Figs. 31 and 37 on Plate XXVI *ante*. An emergency set of 75 kw. capacity, driven by a Diesel engine constructed by Messrs. Mirrlees, Bickerton and Day, is also carried in the emergency dynamo room on the boat deck. The main generators are of the two-voltage type, giving 220 volts for power and 110 volts for lighting, and they are arranged to work in parallel. A complete ring main is fitted around the ship, supplying the power to a number of auxiliary switchboards situated in different sections, which in turn supply the power for motors and kitchen machinery, as well as current for lighting. Each stateroom is fitted with an electric heater and fan, and all special and *cabin-en-suite* rooms are connected to a central exchange by telephone. Motors are used for driving the forced-draught fans and also the fans for ventilating the stokeholds; there are also 12–35 h.p. motor-driven winches for handling cargo. The boat-handling gear, which will be referred to later, is electrically driven, and electric power is also required for the main passenger elevator and for a number of lifts in the store rooms, mail and baggage rooms, engine room and other parts of the vessel. A complete system of "hummers" is installed throughout the passenger accommodation, the arrangements being such that when a passenger requiring attention operates a push button, the call sounds continuously until the steward answers it. All the store rooms, baggage rooms and cargo spaces are fitted with thermostats which give an alarm on the bridge and in the engine room in case of fire; the location of the fire is also indicated. A system of alarm hooters, controlled from the bridge, is also fitted throughout the accommodation for the purpose of calling all the passengers and crew up on to the deck in the event of fire or any other emergency.

Water-Tight Door Installation.

The installation of watertight bulkhead doors fitted is on the Brunton hydraulic system and comprises six horizontal and four vertical doors, power for operating which is supplied by two Weir hydraulic pumps. The pressure fluid is drawn from the supply tank by the pumps and delivered into the mains at a pressure of 700 lb. per square inch. The mains run from the steering-engine room aft, to the forward boiler-room bulkhead directly below the navigating bridge. Branch mains provide connection with the control valve at each door, and the valve controls the supply of pressure fluid to the cylinder operating the door; the force developed in the cylinder is about 6½ tons. In the case of vertical doors, the door shaft giving the necessary movement is fitted directly on to the pinion, gearing with the rack in the hydraulic cylinder, and in the case of horizontal doors a chain-drive is employed. The greatest efficiency is secured by supplying the pressure fluid to the cylinder directly from the main, through the door-controlling valve, and not through the bridge-control valve, the action of which is to control the opening and closing positions of the door valves. At each door there is a hand control and also a bilge-flooding control. The first enables a door, when closed from the bridge, to be opened from either side of the bulkhead, but only while the handle is held. The bilge-flooding control is operated by the rising of a float, which releases a weight and closes the door. The bridge master-control valve is situated on the main deck, and is operated by means of a handle secured to the side of the bridge indicator and connected with the valve by a wire. The bridge lever is fitted with an extended pawl, which, when pressed up to the handle, rings warning bells at every door. The electric indicators are of a special type in which each door is represented by a small electric lamp which lights when the door is closed and simultaneously acquaints the operator at each hand-gear station on deck that the door is closed.

In the Empress of Canada, and other recently fitted ships of the Canadian Pacific Company, a second indicator and full control of the bridge valve have been fitted in the engine room, thus giving the engineer officer in charge, power to close all doors independently of the action of the officer on the bridge. In an emergency, this feature of the Brunton system transfers the control of all doors from the bridge to the starting platform in the engine room. A pressure-indicating valve is fitted on the pressure main, which makes electric contact when the pressure is on and lights a lamp on the bridge. At each vertical door shaft an engaging and disengaging clutch mechanism is fitted which is operated at the door itself from either side of the bulkhead or from the hand-gear station on deck. A valuable feature of the Brunton system is that the door valve is fitted with a device by means of which bunker doors can be left partially open to any extent without interfering with the closing control from the bridge or starting platform.

Lifeboat Equipment.

Thirty-two Murray and Clemson type lifeboats are carried on the vessel, including a motor boat, and these are sufficient to accommodate the whole of the passengers and crew. All the boats are stowed on the boat deck excepting two, which are placed on the after part of the promenade deck. The method of lowering and raising the boats is by Babcock and Wilcox patent double-acting davits and Welin davits, both of which are visible in the view of the vessel taken from the navigating bridge and reproduced in Fig. 2 on page 255 *ante*. The boats under the Babcock and Wilcox davits are arranged on skids, and two sets are fitted to work each group of 10 boats on either side of the vessel. The davits consist of two composite tubular posts connected by a cross tube and fitted with derrick levers in rigid connection with cam-shaped head pieces, and they are arranged to plumb within 8 in. of the centre line of the deck so that the boats may be slung from one set of posts to the other. The davits, which are normally worked electrically, can also be operated by hand, but when motor-driven, a fully-loaded boat, weighing about 10 tons, can be hoisted at a speed of 25 ft. per minute, and loads up to 2 tons can be hoisted at a speed of 120 ft. per minute; a fully-loaded boat can be traversed at a speed of 50 ft. per minute. There

THE CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; DOUBLE-REDUCTION GEARING.

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, GLASGOW.

Fig. 51. LONGITUDINAL SECTION THRO' C.L. OF GEAR CASE.

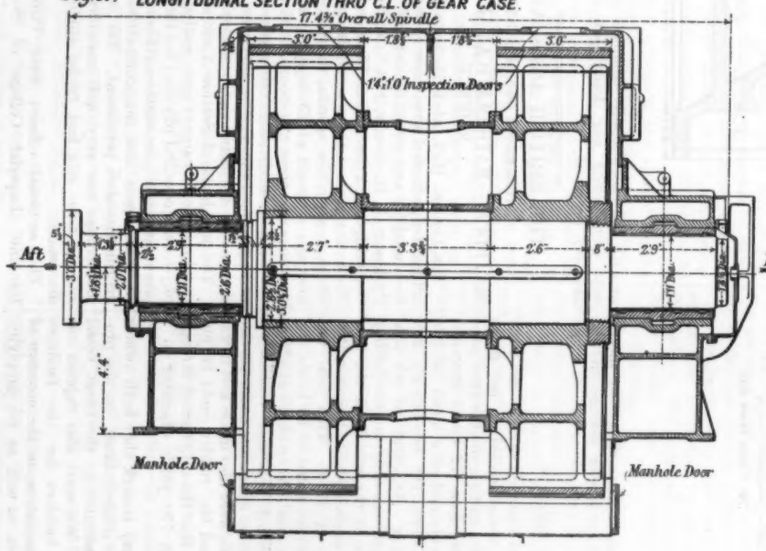


Fig. 52. PORT GEAR CASE. LOOKING FORWARD
HALF SECTION THRO' BEARING CENTRE OF TURBINE PINION SHAFT.
HALF SECTION THRO' CENTRE LINE OF GEAR CASE.

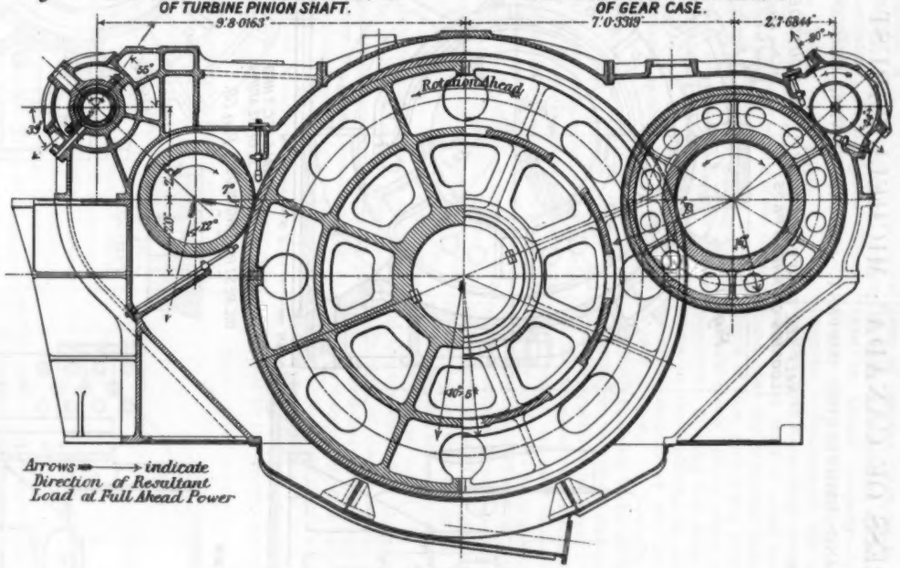


Fig. 53. HORIZONTAL SECTION OF INTERMEDIATE GEAR WHEEL SHEWING MAIN GEAR WHEEL IN MESH.

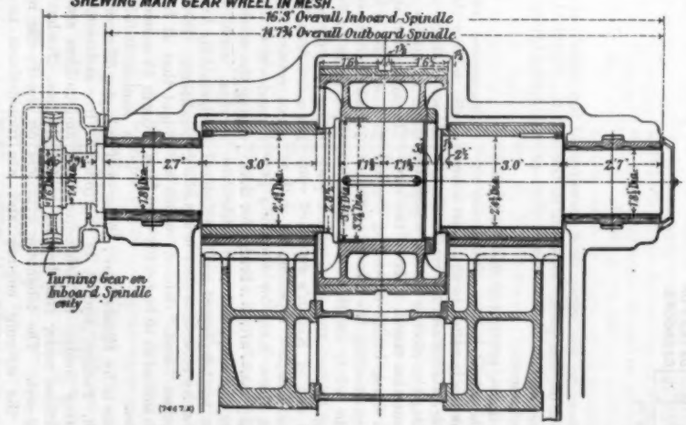
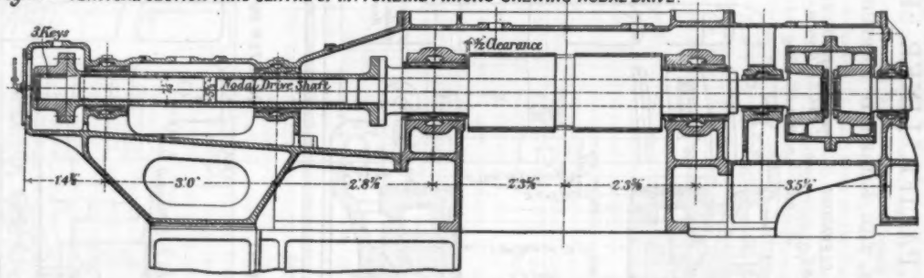


Fig. 54. VERTICAL SECTION THRO' CENTRE OF I.P. TURBINE PINIONS SHEWING NODAL DRIVE.



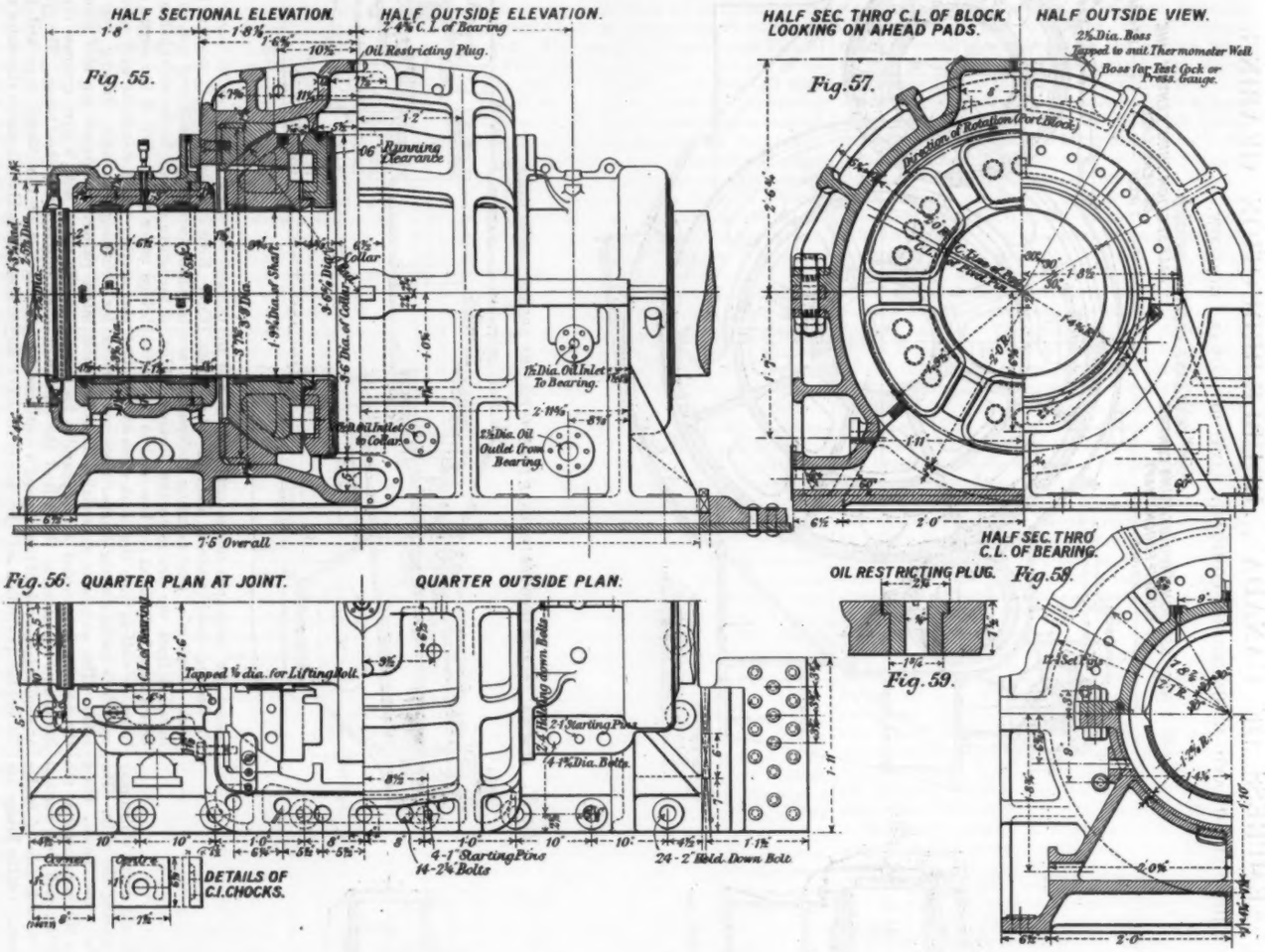
are also twelve sets of Welin davits having one lifeboat under each, the davits being so shaped that the lifeboats, when stowed, are raised sufficiently to allow the deck space under them to be utilised.

Navigating Appliances.

Every provision has been made to bring the navigating officer into touch with any event which may arise in the course of navigating the ship. The navigating bridge with the wheel house, chart room and pilot's room is on the same level as the house tops, and a screen shelter, with large vertical sliding windows, is fitted to each side of bridge and in front of the wheel house. On the bridge are placed the telegraphs to the engine room and to the steering, docking, anchor and look-out positions, while Graham's loud-sounding telephones are installed from the bridge to the docking bridge, crow's nest, look-out at the bow, and to the engine room, as well as from the chart room to the chief engineer's room, steering compartment and wireless room. The whistle is electrically controlled, and the foghorn is provided with apparatus for bringing it into use either at the will of the captain or at required intervals of time during a continued fog. To enable the officer of the watch to have an unrestricted view when rain or snow is falling, three Kent's "clear view" screens have been installed, two on pedestals and one on a window of the centre screen. In the wheel house and on the bridge under the shelter of the centre screen, are the steering wheel standards with telemotor gear for actuating the main steering gear. Kelvin's latest pattern compasses are also fitted at each steering wheel with a gyro compass repeater over the compass in the wheel house. The gyro compass installed is of the Brown type and the master compass, switchboard, motor alternator and battery

THE CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; MICHELL THRUST BLOCK

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, GLASGOW.



are placed in a room on the upper deck forward. Repeaters are fitted on the bridge forward, in the captain's day room and in the wireless cabin, as well as in the wheel house.

The watertight doors, previously dealt with, are controlled from the wheel house. Submarine signalling instruments are installed in the chart room, together with the fire alarms and the master electric clock for controlling the electric clocks which are installed throughout the vessel. Above the navigating bridge is a flying bridge extending the full breadth of the ship, enabling the officers to have a clear view over the whole length of the vessel to the after docking bridge, and on a raised platform is mounted one of Kelvin's standard compasses and a gyro-compass repeater, as well as semaphores and a Morse lamp for signalling purposes. Above "B" deck, aft, is a bridge for docking and undocking the ship, and both bridges are in communication by telephones and mechanical telegraphs as well as by reversible electric signalling lamps, showing "clear" and "danger," which are placed one on each side so as to be readily seen from the forward bridges.

The steering gear is by Messrs. Bow, McLachlan and Co., Limited, Paisley, and it is controlled from the navigating bridge by telemotors and from the wheel house under the docking bridge by mechanical means. The telemotor cylinders are placed near the steering engines and are connected by levers and shafting to the steam-control valves of the engines. The precise position of the rudder at any moment is shown by means of an electrical helm indicator placed on the navigating bridge.

TRIAL RESULTS.

Progressive trials were carried out on the Skelmorlie mile with the vessel loaded to her mean service draught of 27 ft. and six double runs were made at speeds ranging from 12 knots upwards. The maximum speed obtained as a mean of two runs was 20·3 knots, with 111 revolutions, and 24,000 shaft horse-power. An extended sea trial of 365 miles to Falmouth was also run, the loading being so arranged that at the middle of the trial the mean draught was again equal to the estimated mean service draught of 27 ft. This trial was carried out at the contract speed of 20 knots and during the whole of the trial all the ship's auxiliary services, such as lighting, heating, ventilation, refrigeration, &c., were in operation under service conditions. Circle trials were also made and it was found that at full speed the rudder could be put over in 15 seconds and that the ship turned through a semi-circle of about 770 yards diameter in 2 minutes 53 seconds.

In conclusion, we may remark that both owners and builders are to be congratulated on the production of what is undoubtedly the finest vessel on the Pacific route. We must also express our indebtedness to the builders for the facilities granted to our representative on the occasion of the trials in April last, as well as for supplying us with the exceptionally complete drawings and data from which our description of the vessel has been prepared.

THE BRITISH ASSOCIATION.

(*Continued from page* 359.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

THE Central Hall, at Hull, in which Section A deliberated, afforded ample space, but it had rarely been used for any scientific demonstrations before Professor G. H. Hardy, F.R.S., of Trinity College, Cambridge, took the chair on Thursday, the 7th inst. Reckoning each of the several discussions only as a single item on the agenda, the Section during the meetings disposed of 23 items by sitting on four mornings and three afternoons. On two occasions the Section subdivided into a general department and a cosmical sub-section, the latter joining other sections for discussing meteorological problems.

The presidents of Section A are chosen in rotation from the domains of pure mathematics, general physics and cosmical physics; but though this year's president was a pure mathematician, magnetic and electric papers and communications on scientific instruments were prominent. The interest in the proceedings was very well sustained throughout, and the time rule had to be applied to all the discussions.

The sectional officers were Professor R. O. Rankine (Imperial College of Science, S.W.),

Recorder, and Messrs. M. A. Giblett (Meteorological Office), H. R. Hassé (Greenwich College), J. Jackson (Greenwich Observatory), A. M. Tyndall (Bristol), and H. G. Forder (Hull) secretaries.

The Theory of Numbers.

In his opening remarks Professor Hardy spoke of the present time as marked by one of the greatest recorded triumphs of pure mathematics, the work of a man who would probably not describe himself as a mathematician, but who had done more than any mathematician to vindicate the dignity of mathematics and to put that obscure and perplexing construction, commonly described as "physical reality," in its proper place. The "reality" of the physicist, whatever it might be (and it was extraordinarily difficult to say), had few or none of the attributes which common sense marked as real. Neither philosophers nor physicists had ever put forward any convincing account of what physical reality was, or explained how the physicist passed, from the confused mass of fact or sensation from which he started, to the construction of the objects which he classified as real. The task which the physicist tried to perform was to correlate the incoherent body of facts confronting him with some definite orderly scheme of abstract relations which he could only borrow from mathematics. A mathematician was not concerned with that physical reality at all. It was impossible to produce by mathematical reasoning any proposition whatsoever concerning the physical world, and only a mathematical crank would now imagine that it was his function to do so. There was plainly only one way of ascertaining the facts, and that was by observation.

The most obvious example of the business of the mathematician—to supply the physicist with a collection of abstract schemes for his selection—Professor Hardy continued, was to be found in the science of geometry. The large number of different systems of geometry, Euclidean and non-Euclidean, of one, two, three or any number of dimensions, were all of equal validity. They embodied the result of mathematicians' observations of *their* reality, a reality far more intense and rigid than the dubious and elusive reality of physics. The old-fashioned geometry of Euclid, the entertaining seven-point geometry of Veblen and the space-times of Einstein and Minkowski, were all equally real. Any of these might fit the facts best; there might be three dimensions in this room and five next door. Members regretted that Professor Hardy did not any further develop these considerations, some of which, he admitted, might appear paradoxical.

In proposing and seconding the vote of thanks to the president, Sir Ernest Rutherford and Dr. G. C. Simpson, director of the Meteorological Office, humorously referred to the introductory remarks, and they also gave expression to the fascination which the number problems have for all of us. A paper on "The Problems of Expressing any Rational Number as a Sum of Powers," subsequently read by Dr. H. W. Richmond, F.R.S., also of Cambridge, further testified to the general interest those questions excite. Describing his paper, quite unnecessarily, as very elementary, Dr. Richmond mentioned that a discussion of this kind had been carried on in the "Lady and Gentleman's Diary" of 1825. He dealt in particular with rational fractions and showed that, oddly enough, as regards sums of cubes the solutions are more easy with fractions than with whole numbers, whilst for sums of squares fractions are quite as difficult to deal with as whole numbers.

There was only one other mathematical paper, the report of the committee on Mathematical tables (Professor J. W. Nicholson, chairman, Dr. J. R. Airey, secretary), dealing with Bessel functions.

The Origin of Magnetism.

The discussion on the "Origin of Magnetism," upon which two hours were very profitably spent, was to have been opened by Professor P. Langevin, of Paris. In his absence, owing to illness, Professor Pierre Weiss, who was to have followed Langevin, introduced the subject. Professor Weiss—then at Zürich, now at Strasbourg—had explained his "magnetons" at the Newcastle meeting of 1915, and we would refer our readers to page 345 of our issue of October, 1915, as to his general views. He believes magnetism to be a molecular rather than an atomic property—for how could the Heusler alloys of unmagnetic metals otherwise be magnetic? Determining the molecular moments, together with Kamerlingh Onnes, at very low temperatures in order to avoid thermal agitation, he found that the magnetic moments of the gram-atoms of iron, nickel, &c., were all multiples of a common factor 1123·5, which he called the gram-magneton; dividing this figure by the number of atoms in the molecule, he arrived at the true magnetic moment of the atom, his magneton $= 18{\cdot}5 \times 10^{-22}$.

At Hull, Professor Weiss stated that according to Langevin, the very feeble paramagnetic phenomena could be explained in terms of the external field and the temperature for bodies each molecule of which had a constant magnetic moment; but that only applied to gases and dilute salt solutions. He (Professor Weiss) had extended these considerations to intense ferromagnetism* on lines similar to the application of the gas laws to liquids of far greater density than the gases. In the interior of any magnetised substance there was a certain field which tended to orient the molecular magnets, and the molecular field H_m represented the effect of the total of the molecular magnets on any of them. That field was represented by the curve shown in Fig. 1; it approached, so far as thermal agitation permitted, the absolute saturation value σ_s. When the substance was placed in an external field H_e, the local field was $H = H_e + H_m$; H_e itself was represented by the straight line of Fig. 1. The two

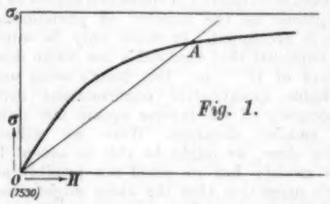


Fig. 1.

curves intersected at the origin O and at the point A; A marked the "spontaneous" magnetisation (per unit mass) in the stable state. Magnetisation of iron did not take place at the moment of exciting the external field; the iron was always magnetic, but it did not always appear so because the molecular magnets were, by local discontinuities and anisotropic properties, prevented from orienting themselves. We might add, perhaps, that Professor Weiss thinks more of demagnetisation than of magnetisation.

All strong magnetisation, he continued, vanished when the iron was heated up to the Curie point (formerly known as the transformation point), and above that temperature the magnetisation, which was always a fraction of the absolute temperature, became inversely proportional to the excess of temperature over the Curie point. Now the specific heats of ferromagnetic metals, like those of other metals, increase with increasing temperature, but they dropped at the Curie point, that is to say, their specific heat was too high relatively from absolute zero up to the Curie point by an amount which corresponded to the complete demagnetisation. Theory and experiment agreed as to these features, and also as to a reversible phenomenon, viz., a ferromagnetic substance became warmer when magnetised, and colder when demagnetised. That had come out in experiments on the spontaneous magnetisation where the experiments with magnetite and with alloys like Fe_2Ni confirmed theory, whilst the pure metals, iron, nickel, cobalt, had at first seemed to deviate.

In the experiments referred to Weiss and A. Piccard placed the substance—*e.g.*, a ball of nickel weighing about 1 gram—in a small electric furnace consisting of a tube made of meerschaum (free of iron), only 15 mm. in diameter together with its air and water jackets. This tube was pushed into a hole drilled axially through the two pole pieces of a powerful electro-magnet. It was found that the temperature of the nickel ball rose (and fell) by about 1 deg. C. each time the circuit was closed (and opened), and that this heat change became a maximum at the Curie point, but decreased again afterwards. The Curie point of nickel is 365·5 deg. C., and a great many ballistic magnetic curves, taken at various temperatures, above and below that, were discussed by Professor Weiss.

From these and further studies, partly confirmed by other workers, Professor Weiss concluded that the molecular field in a pyrrhotite crystal had three different values in the direction of its three axes, and further, that the same element would possess a different number of magnetons at different temperatures and under different chemical and physical conditions, *e.g.*, in ferrous and ferric compounds. Thus ferromagnetic nickel had three magnetons near absolute zero, more magnetons at ordinary temperatures, eight magnetons between 800 deg. and 900 deg. C., and nine at still higher temperatures. In its solid paramagnetic salts nickel would seem to contain 15 or 16 magnetons, in salt solutions 16 magnetons. Some magneton values came out fractional in experiments, although one should expect integer numbers. Professor Weiss presented two conclusions: that (1) magnetic atoms are the seats of characteristic moments which vary in a discontinuous manner according to the state of the body, and which are integral multiples of a single definite elementary moment, the magneton; (2) intense magnetism or ferromagnetism is the result of the existence of the mutual orientation effects of the magnetic molecules which are expressed by the molecular field. An attempt to bring the magneton into harmony with the Bohr-Planck theories, Professor Weiss added, had been made by Einstein; why its calculated value came out nearly five times too great, he could not say.

Sir J. Alfred Ewing, rising first after Professor Weiss, expressed his admiration for the work of Professor Weiss which, in the extended form in which it was now presented, would require very intimate consideration. He proceeded to explain the reasons which had induced him to modify his molecular theory of induced ferromagnetism—which was received with enthusiasm at the Leeds meeting of 1890. That 1890 model of pivoted magnets, based upon Weber's conception of molecular magnets, had failed quantitatively; to turn the little magnets would require thousands of times the force actually needed to produce ferromagnetism, and if the atoms themselves were to turn, cohesion and crystal structure should be affected by magnetisation, of which we had no evidence. The new models (some of which we illustrated on page 240 of our issue of February 24 last) accounted for some magnetic stress and temperature effects, and were compatible with the Bohr-Rutherford atom. Professor E. T. Whittaker had pointed out that a bombarding electron approaching in the direction of the axis, would set his (Ewing's) wheel model (*e.g.*, with all N. poles at the circumference and the S. poles at the centre) in rotation, and that would constitute a magnetic current. If the speed of the electron fell short of a minimum value, the electron would be returned elastically without loss of energy; if the speed exceeded the limit, the electron would pass through the system, giving up part of its energy and, escaping, would show angular oscillation, *i.e.*, radiation.

Dr. A. E. Oxley, M.A., of the Shirley Institute, Didsbury, who contributed the next paper, referred particularly to the marked influence which hydrogen, itself paramagnetic in both the gaseous and liquid states, exerts on the atomic structure and the magnetism of metals when absorbed by them or combined with them. The specific magnetic susceptibility of palladium black, Dr. Oxley pointed out, fell rapidly as its hydrogen content increased. Now, palladium had 46 electrons, hydrogen had 1, and the diminution in susceptibility was such as if the nature of the combined PdH system were similar to that of silver, which had 47 electrons. Silver differed from palladium-hydrogen, of course, by the distribution of the hydrogen nuclei, and hence possessed otherwise different properties. It would be very interesting to extend these experiments to platinum, which should become less paramagnetic by taking up hydrogen and should assume

* Substances are called paramagnetic when they place themselves axially in a magnetic field, and diamagnetic when they place themselves equatorially. Ferromagnetism is a type of intense paramagnetism.

an electronic configuration similar to diamagnetic gold.

Manganese was another interesting example of these peculiar relations. Itself paramagnetic, pure manganese became ferromagnetic by occluding hydrogen when fused in a hydrogen atmosphere; here again we had: manganese, 26 electrons; hydrogen, 1; iron, 27. If we assumed that in the manganese, when occluding hydrogen, some of the electronic systems were similar to those of iron (that is to say, that the electron of the hydrogen atom had penetrated the outer shell of the electrons of the manganese atom), then we should expect the manganese to be feebly ferromagnetic in proportion to the number of such MnH systems present. Quantitative experiments roughly agreed with that assumption. Again, iron acquired a higher coercive force by being fused in hydrogen; cobalt had a higher coercive force than iron, and there were 27 electrons in the iron atom and 28 in the cobalt atom. Similar considerations could be extended to the systems Mn As, MnS, Mn Bi, &c., and to the Heusler alloys.

As regards the bearing of the suggestions just enumerated upon atomic structure, Dr. Oxley submitted that Bohr's large elliptical orbital motions could hardly supply the directional forces necessary for explaining crystalline and magneto-crystalline properties; the conditions might be different and compatible with Bohr-Sommerfeld, when the atom was radiating. The observations discussed were most easily interpreted by the cubical atom of Lewis-Langmuir* and they indicated, Dr. Oxley thought, that the electron was itself a complex electrostatic and magnetic unit, electrons equivalent to magnetic doublets being of importance in determining cohesion and chemical combination.

Mr. L. F. Bates, M.A., of the University of Bristol, presenting the next contribution, asked the Section to consider what would happen when a thin iron wire was suspended vertically by a delicate quartz fibre and was suddenly magnetised in a direction parallel to its axis. In the unmagnetised state the electrons of the iron probably described orbits oriented in all directions; on magnetisation, the electron orbits would tend to set themselves perpendicular to the axis, and the amount of matter moving about the axis was thus suddenly increased. That would, by Newton's third law, call forth an equal and opposite reaction, and the wire, supposing that a north-seeking pole were formed at the lower end, should turn about its axis clockwise when viewed from above. This effect was predicted by O. W. Richardson in 1908; but actual observations made by various workers, and recently by Dr. Chattock and Mr. Bates (by ballistic methods) showed the effect to be only about half the theoretical, viz., 0·503 for iron and 0·505 for nickel. Eddy currents, they found, would not affect the results by more than a few tenths of a per cent.; the curves which Mr. Bates displayed, testified to very accurate work. The rotating impulse delivered to the wire seemed to be directly proportional to the change of movement. They had tried to determine whether the experimental effect was exactly half that predicted. None of the various suggestions made to account for the lack of agreement between theory and experiment could be regarded as satisfactory, and, Mr. Bates concluded, we should need a greatly increased knowledge of the structure of the atom before a satisfactory explanation could be given.

Sir Ernest Rutherford, opening the general discussion, agreed that we were a long way yet from understanding what magnetism was. The lines of experiments of Professor Weiss, Dr. Oxley and Mr. Bates were very important; but why should the Bates effect be one-half rather than 0·503, and why, in general, that mystic power of whole numbers? Speaking as a non-expert of magnetism, he did not see why Professor Weiss should regard the source of magnetic phenomena as deep-seated; all evidence pointed to surface effect and to linkage. He also inquired about the reliability of Professor Weiss' figures, and how an atom could have 10, 12 and more magnetons in different states. Professor J. C. McLennan, F.R.S., of Toronto, spoke of similar difficulties. The recent work of Professor Weiss was great, but we looked for some physical conception. We knew very little about molecular grouping; the source of magnetism was probably in the atom. Last year (*see* ENGINEERING, September 30, page 468) he had shown that the spectra of sodium and potassium seemed to pass into those of neon and argon when the metals lost one electron; it was very interesting to see that Dr. Oxley obtained an analogous magnetic effect by adding an electron.

Professor F. A. Lindemann, F.R.S., of Oxford, said that he would like to protest against what he considered to be the undue importance attached to the Ewing-Whittaker model. That model might possibly account for the quasi-elastic reflection of electrons at low velocities and the abstraction from them of one quantum of energy when their velocity exceeded a certain value. But that was only one of the many phenomena which had forced physicists to abandon the classical laws of mechanics and electrodynamics. The comparatively gross interactions of atoms and groups of atoms did not obey the ordinary continuous laws, as the study of specific heats at low temperatures showed. Again, the mere existence of a stable atom of dimensions of the order of 10^{-8} cm. was incompatible with ordinary electrodynamics, seeing that Rutherford had found Coulomb's law to hold down to distances of 10^{-12} cm. As regards the Lewis-Langmuir atom and Dr. Oxley's attempt to help it out by suggesting that a static model might be changed to a dynamical one when an atom radiated, that also led to grave difficulties. The Lewis-Langmuir model was little more than descriptive; it contained almost as many assumptions as the number of phenomena for which it accounted. It could only be admitted if we admitted that Coulomb's law broke down at distances of 10^{-8} cm. But Bohr's atom and its remarkable quantitative confirmations involved the accuracy of the inverse square law down to much smaller distances. Were we willing to sacrifice these, we might be able to accept Langmuir's model; but we could not possibly accept Oxley's suggestion that the atom might resemble either model alternately.

Professor Weiss, in replying in particular to Sir Ernest Rutherford, said that he considered magnetic and chemical phenomena to be intimately connected; the chemical properties were ascribed to the outer electrons, but those outer electrons must influence the inner, and in that sense he thought of magnetic phenomena as deep-seated. As regards the reliability of his figures, he admitted that his relative values were better than his absolute; but he thought them correct within half per cent., and that would, in the case of 29 magnetons, make a possible difference of one-sixth of a magneton, With regard to the variable numbers of magnetons he drew attention to the ferro-cobalt alloys and the compound Fe_2Co [compare the 1915 paper quoted above]. That compound—which he recommended as material for pole pieces—was more magnetic than either iron or cobalt; it contained 12 magnetons, and when we started from the alloy and decreased (or increased) the cobalt percentage we came down to an iron with 10 magnetons (against the ordinary value of 11 magnetons for iron) and to a cobalt with nearly 9 magnetons.

STRUCTURAL SIGNIFICANCE OF OPTICAL ROTATORY QUALITY.

A paper of this title, sent by Sir Joseph Larmor, F.R.S., M.P., was read by Professor A. W. Porter, F.R.S., in the author's absence. Sir Joseph pointed out that when substances like quartz exhibited high optical rotation when crystallised, but not when amorphous (fused), the chirality (right- and left-handedness) must be present in the crystalline form, and not in the constituent molecule, the molecule being chiral only in geometrical form, not in the optical structure. That might be possible if the crystalline unit were the charged ion (not the bipolar molecule), and this view was in agreement with X-ray analysis of crystal structure.

Owing to the screw structure of the ionic crystal elements, an impressed electric field would produce a slight magnetisation which was a linear function of its time-gradient (the cause of optical rotation); the ionic twist constituting the magnetisation involved inertia and elastic reaction and thus a period of free oscillation. In most substances the optical rotation persisted in the amorphous state and in solutions; in those cases the molecule would itself be chiral. Sir Joseph referred in his mathematical deductions chiefly to T. M. Lowry and to the quite recent work of L. Longchambon (*Comptes Rendus*, July 17 last) on organic substances; for these substances the rotation per molecule had three different values in the solid, liquid and gaseous states, but these values showed the same ratios for widely-differing radiations.

Commenting upon this paper Professor Porter remarked that Sir Joseph did not appear to have taken into account the investigations of Reusch who, by superposing plates of non-active crystals—each plate being rotated through a fixed angle—obtained all the optical effects characteristic of the rotation of the plane of polarisation. There would then not be any need of the special magnetic term to which Sir Joseph had referred.

SIGNIFICANCE OF CRYSTAL ANALYSIS.

These various problems, and in particular the spiral structure of quartz, were also discussed by Sir William Bragg in his very interesting lecture on "The Significance of Crystal Analysis," which drew a large audience, in spite of the late hour, 5 p.m. We shall revert to this lecture later on.

OSCILLATING VALVES FOR DIELECTRIC AND MAGNETIC MEASUREMENTS.

A paper on "The Application of Oscillating Valve Circuits to the Measurement of Dielectric Constants and Magnetic Susceptibilities," by Mr. J. E. P. Wagstaff, of the Univeristy of Leeds, one of the communications on precise scientific instruments to which the Section rightly devoted a large portion of its time, is mentioned here on account of its bearing on magnetism. Mr. Wagstaff pointed out that the formula for the frequency of an oscillation $N = 1/2\,\pi\,\sqrt{L\,C}$ was applicable to low frequencies produced by tuning forks as well as to high frequencies produced by valves. The product N^2C decreased as the frequency increased, but Mr. Wagstaff had found that when the capacity C was increased by a suitable amount c, $N^2(C + c)$ could be kept constant within wide limits, which meant that the capacity to be considered was not only that of the condenser, but that of the whole circuit which would change with the high-frequency field. This was further proved by measurements of the specific inductive capacity of air by a beat method, which were in excellent agreement with other determinations.

In order to measure low magnetic susceptibilities in steady fields, Mr. Wagstaff makes use of a horizontal parallel-plate condenser, the upper plate of which is rigidly fixed to a steel base, whilst the lower is fastened to a brass rod and so suspended by a wire that it can slide up and down vertically under the torsion of the wire; the apparatus was thus a torsion balance, capable of measuring very small changes of 0·01 dyne. When a uniform cylinder of section A and susceptibility K was suspended from the end of the rod mentioned in a powerful magnetic field, a scale pan being included in the suspended system, the downward pull upon the specimen would be $P = K\,A\,(H_2^2 - H_1^2)/2$, where the H were the values of the magnetic fields at the ends of the specimen. When the current was turned on, the pull was altered by P, and the condenser plates were further separated to a small corresponding amount, which altered the frequency of the circuit; the change in frequency was a linear function of the change in load, and the advantage of the method was that the additional tension need not be determined, measurement of the change in the frequency of the note being alone necessary. The quantity H_2 had also been measured, however, by finding the mechanical force on a circuit (placed between the pole pieces) consisting of two vertical strips of copper, to the bottom of which a horizontal cross-piece of copper was soldered; the frame was suspended from the brass rod, and the current conveyed to the frame through two spiral coils of extremely fine wire. The value of K found for bismuth, viz., $K = -13{\cdot}4 \times 10^{-6}$, was in striking agreement with the accepted value, and consistent

* Discussed last year at the Edinburgh meeting; see "The Structure of the Molecule," ENGINEERING, October 14, 1921, page 529; compare also ENGINEERING, September 17, 1920, page 383, as to Dr. Oxley's views.

results had been obtained with the magnetic liquid, nickel carbonyl.

The Ultramicrometer.

With the aid of diagrams, Professor R. Whiddington, of Leeds, explained "Applications of the Ultramicrometer Principle to the Measurement of certain Physical Quantities." He had described his ultramicrometer at Cardiff (see ENGINEERING, September 17, 1920, page 384). It consists essentially of two oscillating circuits each maintained by a thermoionic valve; the frequency of the first circuit is affected by the capacity change produced by the small motion of one condenser plate towards another; the observer listens to the changes in the beats produced by the change. By attaching one plate of the condenser to a metal rod, fixed at the other end, Mr. Sucksmith had detected temperature changes of 10^{-6} deg. C.; Mr. S. Hare had measured pressure changes of 7×10^{-6} mm. of mercury with the aid of a metal diaphragm. For weight measurements a quartz balance of the Stromberg type and two condensers of aluminium were used by Mr. Long, and the connections were so arranged that as the one capacity increased, the other decreased; mass changes of 4×10^{-9} gram were detected.

Discussing the possibilities of the method, Sir Ernest Rutherford doubted whether the valves and other conditions could be kept steady during the experimental periods (about 15 minutes). Professor Porter pointed out that with the figures given we approached molecular dimensions, and Professor Hardy asked what was meant by moving through a distance of molecular dimensions.

Professor Whiddington admitted difficulties; he experimented at night, and sometimes the apparatus would not work at all. But the method was suited for relative, differential measurements, and he compensated for the changes observed. One has probably an exaggerated idea of the difficulties, though the instrument may be a detector or indicator rather than a meter. The instrument is shielded by metal, but need not be encased in lead; the experimenter may be in the same room; the condenser plates, 1 in. by 2 in., are only polished, and need not be optically plane, nor absolutely parallel; the most sensitive distance between the plates is 0·01 mm.

X-Rays and Light Atoms.

The first of a group of papers on X-rays was a brief communication, by Professor J. C. McLennan, F.R.S., and Miss M. L. Clark, of Toronto, on "X-Rays and Light Atoms." The importance of the paper, which will have to be studied when fully available, lies in the fact that Professor McLenann is closing up the little-investigated gap in the Moseley curve still left between the heavy atoms (*i.e.*, atoms of high atomic weights and numbers) and the lightest atoms, hydrogen and helium. Determining the critical potentials of lithium, beryllium and boron,* which correspond to the K series (coming from the innermost electron) of critical absorption of X-ray wave-lengths, he found that the Moseley law connecting the frequency of the critical absorption with the square root of the existing potentials applied down to lithium. It would further appear that the Lyman (ultraviolet) series of hydrogen was the K X-ray series for this element, and that the convergence wave-length of the K series for helium was $\lambda = 485{\cdot}5$ A.U.

New series of critical potentials, representing apparently the convergence wave-length and the first members of the L series, had also been determined for lithium, beryllium, boron and carbon; in these cases the square roots of the critical volts were found to be directly proportional to the atomic number of the elements. There was hence support for the view that the Moseley law, known to hold for the L series of heavy elements, would cease to apply for elements lighter than argon. That would have a bearing on the grouping of the electrons in successive rings, whether 2, 8, 8, or 2, 16 possibly. The experiments are made by speeding up the electrons in Coolidge tubes, into the copper target of which a button of lithium, &c., is fixed, and by measuring the photo-electric effects at the sudden changes in the radiations called forth by the critical potentials.

* The atomic numbers are: lithium 3, beryllium 4, boron 5, carbon 6.

X-Rays and β-Rays.

The discussion on this subject was introduced by the Duc de Broglie, who gave a very able *résumé* of the fundamental problems. There was a close connection between light and electrons, he stated; the real nature of light, corpuscles of great velocity or high-frequency wave motion, was still an open question. The relation between the energy of the corpuscles and the frequency of the vibrations was (Planck-Einstein) of the form $W = h\nu$. X-rays were excited by the impact of cathode rays on the anti-cathode; there was first ejection of corpuscles and then wave radiation. Light carried something and brought out electrons which were emitted at a speed connected with the frequency of the exciting light. The continuous background of the spectrum emitted when the anticathode was bombarded by electrons of energy W began on the short wave-length side at a maximum frequency $\nu_m = W/h$. As regards characteristic rays, we knew now that all the fluorescent rays of a certain series appeared simultaneously in the bulb when the energy of the cathode reached a value exceeding the quantum $h\nu$ of the discontinuity of absorption relative to this series. That the emission of Barkla's secondary rays was closely connected with critical values of the velocity of the cathode rays had first been demonstrated by Whiddington.

The converse phenomenon was the question of the rapidly moving electrons liberated by matter when illuminated by X-rays. That phenomenon obeyed the general law of photo-electric effects, viz., the individual energy of the corpuscles expelled depended only upon the frequency and not upon the intensity of the existing radiation, and it was bound up with the levels of energy which the theory of Bohr had pictured in the structure of the atoms. If the levels were indicated by the letters K, L, M . . ., we could attribute to them energies of extraction W_K, W_L, W_M . . . When light of frequency ν struck one of those electrons, situated, *e.g.*, in the K region, it communicated the energy $h\nu$ in order to extract an electron from the atom; the corpuscle, once removed from the atomic edifice, would possess the resultant energy $h\nu - W_K$. That form of the equation was proposed by Einstein for photo-electric phenomena, and used by Rutherford recently to specify a possible connection between the natural β and γ rays of radioactive substances. Certain experiments had induced Barkla to believe that all the β rays excited by a beam of monochromatic X-rays had the same energy; but Lewis Simons had pointed to the role of energy levels. By the method of the magnetic spectra of β-ray velocities we could analyse the complex bundles of corpuscles emitted by a radiator under X-ray illumination; we found all the expected groups of electrons, and this analysis was supported by the crystal analysis. Finally, Ellis* had recently shown that the X-ray relations extended also to γ-rays.

The interest of the exposition by the Duc de Broglie was increased by his showing many of his new remarkable photographs of absorption spectra of various series.

X-Ray Electrons.

Professor Whiddington, next called upon, describing his recent work on X-ray electrons, said that the main difficulty was to get powerful X-ray illumination. The Duc de Broglie had used a Coolidge tube; in his water-cooled quartz bulb he (Whiddington) had been able to exceed the output of those tubes. His target was faced with rhodium, and the rays were reflected downward through a slit and curved by the field struck the plate from below. The spectra were comparatively simple, and the line positions could be defined in terms of the incident X-ray frequency and of the atomic number of the illuminated atom (rhodium). Nuclear electrons, such as those investigated by Ellis, were not affected by these experiments, because the available X-ray energy was insufficient.

Sir Ernest Rutherford, speaking first on these papers, paid a tribute to the admirable work of the Duc de Broglie, the difficulties of which were very great. To come up to the γ-ray level, we should have to use millions of volts, instead of the 70,000 volts of Broglie. The further discussion turned on some puzzling facts, such as the apparent continuous X-ray spectra.

Professor F. A. Lindemann, having congratulated the authors of the papers on their skill, the sharpness of their β spectra lines and the accuracy of their measurements within 0·1 per cent., referred to the Duc de Broglie's remarks on the importance of explaining the continuous background of the spectra. If the intensity of the background varied with the secondary radiator (Whiddington), the background could not be due to the continuous X-ray spectrum of the primary radiator. The rhodium anti-cathode produced in any case little continuous spectrum, which must therefore be due to a difference in the loss of energy from the β particles which had absorbed a quantum. Loss in penetrating the metal would only result in the lines being shaded toward the long-wave (small-energy) side, but not in a continuous darkening. That darkening seemed to involve the presence of electrons in all states intermediate between the stationary states, as suggested in the "Nullpunkt-energie," but quite at variance with accepted notions. The fact that comparatively slow electrons of low frequency, such as the L and M electrons of silver and copper, could absorb a large quantum, such as that of the K radiation of tungsten, seemed also of the utmost importance. One seemed justified in assuming that a free electron in space would absorb the same energy. If that were so, it would dispose altogether of any idea of resonance or any similar process in absorption phenomena, although Planck, of course, tried to save this relic of the classical electrodynamics out of the wreck.

Sir William Bragg, having expressed his admiration for the work and lecture of the Duc de Broglie, also referred to the continuous background. X-ray bulbs seemed to give characteristic and general radiations independently of one another. One might expect that the two types of radiations, corpuscular and wave, would continuously interchange, and since the electrons were losing speed all the time, we obtained all sorts of rays, no matter what we started from.

In his brief reply, the Duc de Broglie touched upon the thermodynamical side of the problems and upon the parallelism between emission and absorption of wave light.

(To be continued.)

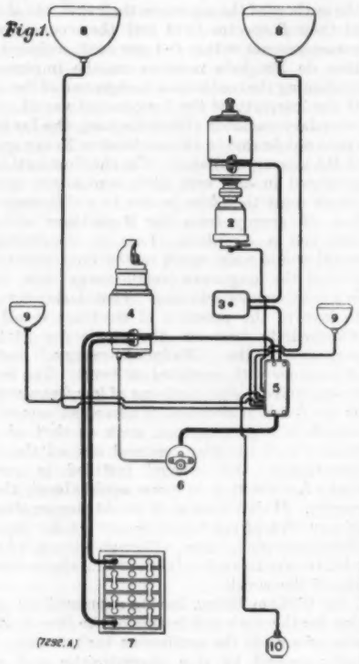
* Compare ENGINEERING, April 14 last, pages 464 and 465, as to Ellis and Magnetic Spectra.

BUSINESS TRAIN THROUGH CANADA.—In order to bring British manufacturers in touch with consumers in Canada, it is proposed to run a special train across the Dominion and back, calling at every city and town of importance on its journey. The train would consist of cars fitted up as show rooms of goods of all kinds, and accompanied by qualified salesmen. The stoppage in the various towns would last from one to seven days, and the train would be preceded by an advertising agent who would interest the business community in its arrival. Starting from Sydney, Nova Scotia, the principal cities visited would be New Glasgow, Montreal, Ottawa, Winnipeg, Prince Albert, Edmonton, Kamloops, Vancouver, then back *via* Calgary, Medicine Hat, Regina, Saskatoon, Brandon, Port Arthur, Kitchener, Hamilton, Toronto, Montreal, St. John and Halifax. The promoters of the enterprise are the British Train Traders, Limited, of Canada House, 42, Blackfriars-road, London, S.E. 1, with whom manufacturers interested in the project should communicate.

THE SQUEEGEE ROTARY PUMP.—In our issue of October 19, 1919, we illustrated an ingenious form of rotary pump for small powers, manufactured by the Avamore Engineering Company, Limited, of Haslemere, Surrey, and sold under the above title. The special feature of the pump was a cylindrical rubber belt surrounding a drum, the latter being freely mounted on an eccentric. The rotation of the eccentric shaft caused the drum to roll on the rubber belt round the inside of a cylindrical casing containing a spring abutment plate at one point. This action caused water or other liquid to enter the casing by one branch and to be expelled at the other. We have recently received particulars of an official test on one of these pumps, supplied to pump water against a head of 120 ft. at the rate of 550 gallons per hour. The pump was direct coupled to a direct-current motor rated at 1 b.h.p., and running at 875 r.p.m. With a suction lift of 8 ft., the pump delivered 600 gallons per hour against a total head of 132 ft., the motor taking only 17·5 amperes at 54·5 volts. The water horse-power was 0·40 and the mechanical efficiency of the pump exceeded 47·5 per cent., a result which appears exceedingly good for so small a machine. With a closed suction the pump would hold a vacuum of 28 in.

THE MIDGLEY-SCHOLEY ELECTRIC EQUIPMENT FOR MOTOR VEHICLES.

CONSTRUCTED BY MESSRS. SCHOLEY AND CO., LIMITED, ENGINEERS, LONDON.



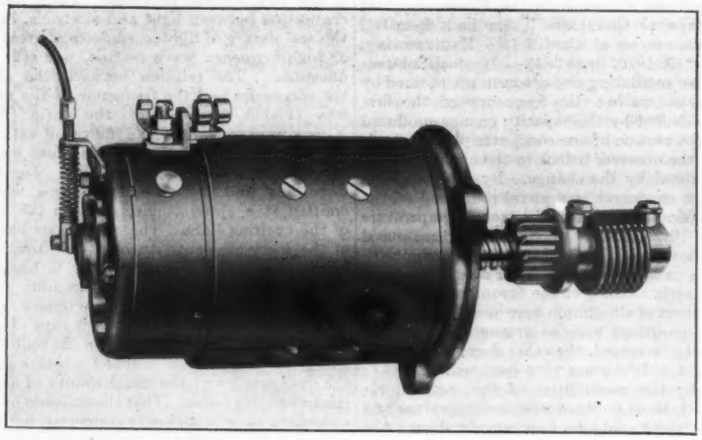


FIG. 2. THE MIDGLEY-SCHOLEY DYNAMO.

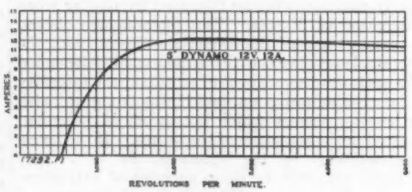
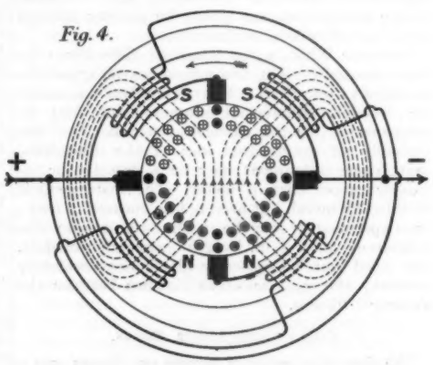
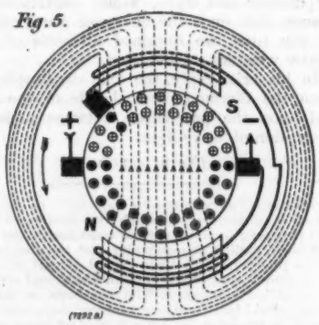
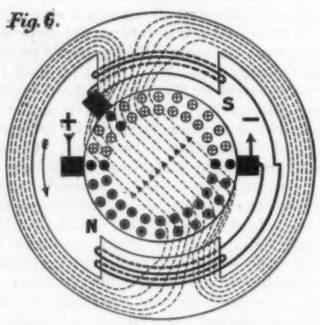


FIG. 3.







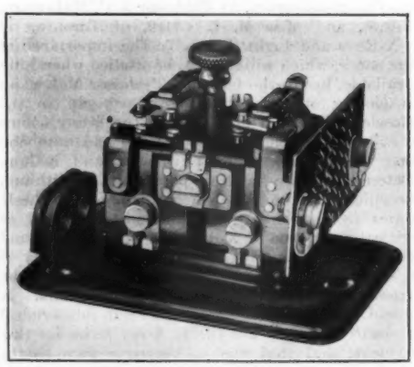


FIG. 7. CONTROLLER AND CUT-OUT.

ELECTRICAL apparatus for starting and lighting now forms part of the standard equipment of the modern motor car, and several systems have been devised to meet the conditions of service. Like all arrangements which have evolved in the direction of complexity, starting and lighting systems as a general rule show crudities which are a relic of their earlier simplicity. At a certain stage in design it becomes desirable to reconsider the fundamentals of the problem, and in the case of the electric equipment of motor cars this has been done by Mr. A. H. Midgley, whose designs are embodied in the apparatus manufactured by Messrs. Scholey and Co., Limited, of 56, Victoria-street, London, S.W. 1. This apparatus, which is made throughout at the company's works at Croydon, is illustrated on this and the opposite pages.

Fig. 1 is a diagram showing the wiring connections. The various pieces of apparatus are identified by numerals, 1 being the dynamo; 2, the magneto; 3, the controller; 4, the starter; 5, the junction box; 6, the switchboard; 7, the battery; 8, the head lamps; 9, the side lamps; and 10 the tail lamps A photograph of the dynamo is reproduced in Fig. 2. These dynamos are built in four sizes, varying from 3·5 in. to 5 in. diameter, and constructed either for flange or saddle mounting, with or without ignition arrangements. The series of 6-volt machines have outputs ranging from 6 to 15 amps., while the 12-volt machines range from 8 to 12 amps. The characteristic curve of a 12-volt machine is reproduced in Fig. 3. It will be noted that at all speeds above 2,000 revs. the output is practically constant, the difference of current between 2,000 and 5,000 revs. being considerably less than one ampere. Fig. 4 shows the principals of design by which this characteristic is obtained. The advantages of the design will be made evident by comparison with the more usual design of variable speed dynamos of this class.

Most car-lighting dynamos on the market are built on the three-brush principle shown diagrammatically in Figs. 5 and 6. When one of these dynamos is at rest the magnetic flux follows the dotted lines in Fig. 5. When the dynamo is working, the field due to the armature current reacts on the main field, and distorts the flux as shown in Fig. 6. This decreases the flux cut by the conductors between the negative brush and the third brush, and therefore diminishes the voltage between these brushes. The current through the field coils is thus weakened more or less proportionally to the armature current, which in turn depends upon the speed. Hence a reasonably constant voltage between the main terminals is secured with varying speed. It is an inherent defect of this design that both the third brush and the main brushes are working in strong fields, particularly at high speeds, with the consequence that sparking occurs due to the heavy current generated in the short-circuited coils. Shifting the main brushes round the commutator only makes matters worse, as it results in even greater distortion of the field. If the brushes are even tilted the behaviour of the dynamo is affected, so that great care has to be taken to see that they are properly bedded down on the commutator.

In the Midgley-Scholey design, shown in Fig. 4, there are four poles and two auxiliary brushes. No distortion of the field occurs and all brushes work constantly in neutral positions, so that the necessary conditions for sparkless commutation at all speeds are provided. The machine is really of the bipolar type, because the two upper poles are both of the same polarity, the two lower ones being of course both of the opposite polarity. Each pole has its separate field coil as shown, the connection being clearly illustrated in the diagram. The two coils connected across the main brushes produce the main field. The other coils connected between the main and auxiliary brushes produce the regulating field. The strength of the latter depends upon the voltage generated in the conductors under the main poles, which again depends on the resultant field produced by the main field coils and the demagnetising action of the current on the conductors under the regulating poles. The demagnetising

THE MIDGLEY-SCHOLEY ELECTRIC EQUIPMENT FOR MOTOR VEHICLES.

CONSTRUCTED BY MESSRS. SCHOLEY AND CO., LIMITED, ENGINEERS, LONDON.

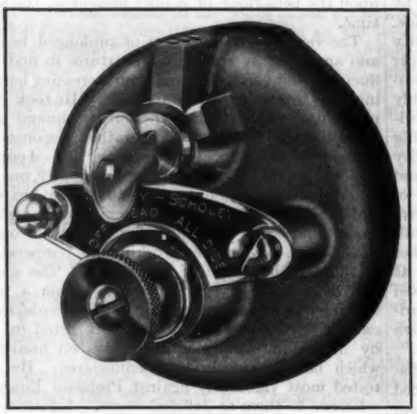
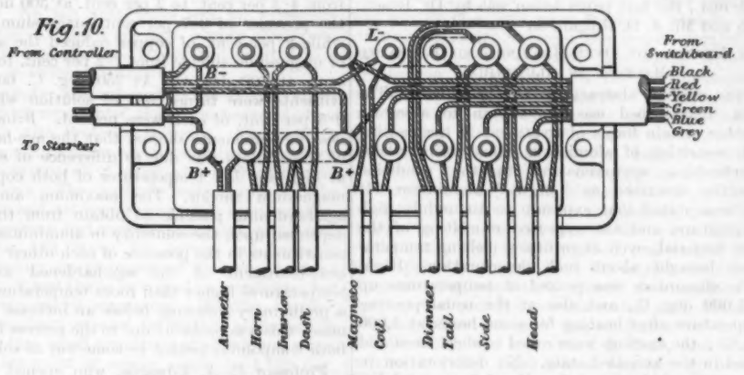
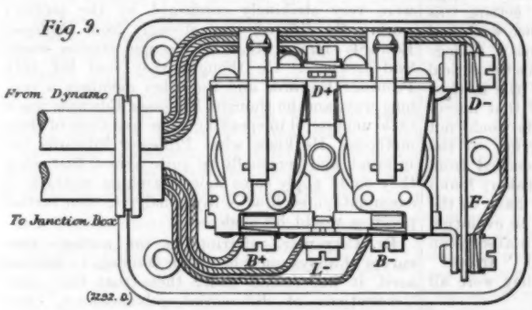


FIG. 8. SWITCH AND LOCK.





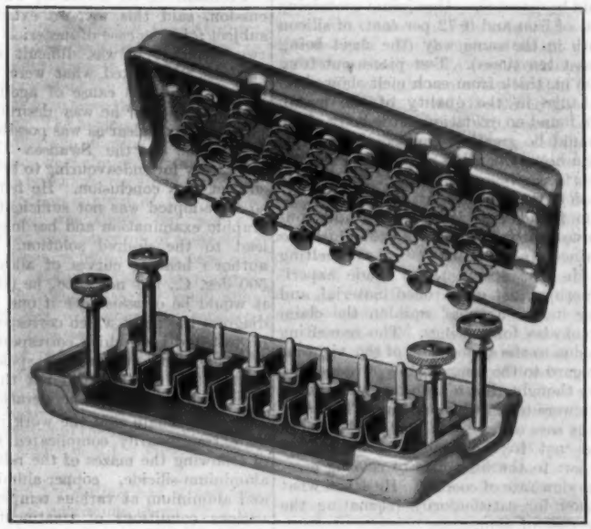


FIG. 11. JUNCTION-BOX AND COVER.

force does not distort the field but merely weakens it, so that the brushes are at all times in the most favourable position for sparkless commutation.

Experience has shown that constant voltage dynamos are unsuitable for car lighting because the voltage necessary fully to charge the battery is more than is good for the lamps. Moreover it is also too high to put across the battery when the latter is run down, and thirdly, the constant voltage system does not permit of raising the voltage when it is necessary to charge a sulphated battery. For these reasons it has been abandoned in favour of the constant current system which suits the battery under all conditions. It does not, however, automatically prevent overcharging, and the driver is expected to switch off his dynamo when the voltmeter, if one is fitted, shows a certain voltage. In the Midgley-Scholey system the battery is protected by a combined controller and cut-out, which is illustrated in Fig. 7 with the cover removed. This device is of a robust nature, without vibrating contacts or other sources of trouble. It has a positive action and serves to disconnect the dynamo from the battery, whenever the former falls below the minimum generating speed, which usually corresponds to a car speed of about 7 miles per hour. This, of course, prevents the battery discharging back through the dynamo. When the speed rises sufficiently to recharge the dynamo, the connection is automatically re-made. When the battery is fully charged, the device automatically inserts a resistance on series with the fields of the dynamo and thereby reduces its output to a minimum. Immediately the lamps are switched on, the dynamo is automatically restored to the full-output condition. The device, which is extremely neat and compact, is usually mounted on the back of the dashboard.

The switch and lock is shown in Fig. 8, above. It only occupies a space 3½ in. diameter behind the instrument board, and all that appears on the front is a Yale-pattern lock and a milled head, with pointer and plate to indicate the position of the switch. On inserting the key and turning the lock both the magneto and coil-ignition circuits are made. Pulling the milled knob forward puts the self-starter into action. Turning the knob from left to right puts different combinations of head, side, and tail lamps into circuit. The switch can be locked with any combination of lamps alight, and when thus locked it is impossible to operate the lamps, self-starter, or ignition. The device is extremely neat and combines security with particular simplicity of operation.

In the Midgley-Scholey system particular attention has been given to the wiring of the car and the connections of the various pieces of apparatus. The general layout of the wiring has already been illustrated in Fig. 1, from which it will be understood that the whole of the wiring up to the junction box can be made a permanent fixture to the chassis. Fig. 9 shows the connections of the controller and cut-out already illustrated in Fig. 7, and as will be seen the terminals are all accessible although perfectly protected. Fig. 10 gives details of the connections in the junction box for an insulated return system. The same units are employed for either system, the connection only being slightly altered in the two cases. The principle on which the junction box is constructed is illustrated in Fig. 11. No screws or nuts whatever are used for the electrical connections. The end of every cable terminates in a washer, and these washers are slipped over the ends of the metallic studs which project from the insulating base. Mounted on insulating strips on the inside of the cover are coiled springs, which, when the cover is in position, pass over the studs and hold the terminal washers firmly on their respective studs. The cover is held in position by four steel studs with milled nuts. There is thus no twisting or cutting of the wires or cables when making connections, and no amount of vibration can loosen any of the connections when the cover is in position. The junction box cover is of aluminium, the box being usually fitted in a convenient position on one of the side frames of the chassis.

From the brief description which we have given, it will be recognised that the Midgley-Scholey system represents a thorough revision of the design of car lighting equipment, with the idea of rendering every item of the apparatus as efficient as possible for the purpose it has to fulfil. The self-regulating feature of the dynamo, and the way it is obtained are particularly noteworthy and the neatness of the whole arrangement is commendable.

"LLOYD'S REGISTER OF SHIPPING."—The returns of "Lloyd's Register of Shipping" for the quarter ending March 31 last show that during the quarter the total number of vessels lost, condemned, &c., was 86 of 99,734 tons. In these figures, those for the United Kingdom enter for 22 vessels and 21,077 tons, and the British Dominions for 5 of 3,193 tons. Of the same total figures, 62 vessels were of steel, of 78,183 tons; of iron, 4 of 3,003 tons; of ferro-concrete, 2 of 7,210 tons; of wood, and composite, 18 of 11,338 tons. The total figures for sailing vessels were 44 of 24,434 tons.

LARGE TURBO-ALTERNATOR FOR MONTEVIDEO.—An important call for tenders for the Uruguay State electric light works at Montevideo has been reported to the Department of Overseas Trade by the British Vice-Consul at Montevideo. Tenders are required for a 10,000 kw. horizontal turbo-alternator complete with condensing plant and accessories. The turbine is to be preferably of the impulse type throughout, but may be combined impulse and reaction. It is to run at 3,000 r.p.m. The alternator is to generate 6,000-volt three-phase, 50-cycle current. The whole of the conditions appear to be in line with English practice, and it is to be hoped that British firms will make a proper effort to secure the order, and in view of the fact that quotations are to be made only in Uruguayan gold pesos, will refrain from quoting in sterling f.o.b. Liverpool or equal. It is stated that local representation is essential. A copy of the specification in Spanish may be inspected at the offices of the Department of Overseas Trade, Room 49, 35, Old Queen-street, Westminster, S.W. 1.

THE INSTITUTE OF METALS.

(*Continued from page* 372.)

On the members reassembling in the Llewellyn Hall, Y.M.C.A., on the morning of Thursday, the 20th inst., the first paper taken was by Dr. Rosenhain and Mr. J. D. Grogan, on

The Effects of Over-Heating and Repeated Melting on Aluminium.

It was read in abstract by Dr. Rosenhain. The work it described was undertaken to ascertain whether certain forms of treatment in the melting and re-melting of aluminium would bring about deterioration approximating to the condition generally described as "burnt" aluminium. It has been stated that exposure to an unduly high temperature, and also repeated re-melting of the same material, even at ordinary melting temperatures, brought about such deterioration. High-grade aluminium was poured at temperatures up to 1,000 deg. C., and also at the usual pouring temperature after heating for some hours at 1,000 deg. C.; the castings were rolled to sheet form and tested in the annealed state. No deterioration in the metal could be detected. Aluminium containing 0·77 per cent. of iron and 0·72 per cent. of silicon was dealt with in the same way (the sheet being melted and cast ten times). Test pieces cut from the sheet 0·05 in. thick from each melt showed no systematic change in the quality of the metal. Dr. Rosenhain found no oxidation in the body of the metal, and would be greatly surprised if a sample could be shown him evidencing oxidation otherwise than on the surface.

The discussion was opened by Professor C. A. Edwards, who found that the paper would conclusively remove some false ideas which had hitherto been entertained in the matter of re-melting aluminium. He (the speaker) had made experiments with castings, not upon rolled material, and asked whether in the authors' opinion the claim made held good also for castings. The re-melting difficulty was due to the application of too vigorous stirring. In regard to the temperature of re-melting he had always thought that a high one was advantageous if care were taken when casting. The chief objection in the case of both sand and chill castings had reference, not to the re-melting at a high temperature, but to the high rate of casting combined with the slow rate of cooling. He asked what was the method for satisfactorily estimating the oxygen in the case of aluminium?

Dr. A. G. C. Gwyer welcomed the fresh facts contained in the paper, since the aluminium alloys were comparatively new metals. The facts brought out in regard to the re-melting of aluminium were very important from the point of view of the utilisation of scrap, and this came in both for castings and for rolled material. In ordinary circumstances it had been found that repeated re-melting resulted in a worse quality, and in this connection it should be remembered that aluminium was a very difficult metal to handle. The oxygen content of aluminium must be extremely low and, like the previous speaker, he would like the authors to point out the method followed for determining the oxygen. Like the previous speaker, also, his experience was that the reheating at a high temperature prior to casting, so that the metal should flow freely, was not bad, but that the trouble had reference to the cooling.

In the course of a brief reply, Mr. Grogan said that they had considered aluminium as castings unsatisfactory to test, this made it desirable to roll the metal for obtaining more satisfactory tests. In regard to the oxygen content, this was a very difficult subject and a fully satisfactory method had not yet been evolved; the point was still under examination.

Age-Hardening of Aluminium Alloys.

The second paper was the one having the title, "The Constitution and Age-Hardening of Alloys of Aluminium with Copper, Magnesium, and Silicon in the Solid State," contributed by Miss M. L. V. Gayler, who read it in abstract.

It stated that these alloys had been regarded as of the ternary system aluminium-copper-magnesium silicide, since magnesium and silicon were added in the proportions of the compound magnesium silicide. The solubilities of copper and magnesium silicide in solid aluminium were determined at 500 deg. and 250 deg. C., and microscopic examination showed that the solubility of copper was reduced from 4·5 per cent. to 2 per cent. at 500 deg. C. by the presence of 0·7 per cent. magnesium silicide, while 2 per cent. of copper reduced the solubility of magnesium silicide from 1·2 per cent. to 0·7 per cent. at 500 deg. C. At 250 deg. C. both constituents were turned out of solution when only 0·5 per cent. of each were present. Brinell hardness measurements showed that the age-hardening of these alloys was due to difference of solubility at high and low temperatures of both copper and magnesium silicide. The maximum amount of age-hardening possible to obtain from the alloys depended upon the solubility in aluminium of both constituents in the presence of each other. Further heat-treatment of the age-hardened alloys at temperatures higher than room temperature caused a preliminary softening before an increase in hardness; this was probably due to the process by which both compounds tended to come out of solution.

Professor C. A. Edwards, who opened the discussion, said this was an extremely complicated subject; in the case of materials having more than two elements it was difficult to arrive at conclusions. He asked what were the views of the author as to the cause of age-hardening at high temperatures, for he was desirous of getting this point made as clear as was possible, since work had been done in the Swansea University College laboratory for endeavouring to bring this theoretical subject to a conclusion. He felt that the method so far adopted was not sufficient, and that micrographic examination and hardness tests would not lead to the desired solution. Referring to the author's heating curves of alloys quenched from 500 deg. C., but not aged, he (the speaker) found it would be of assistance if one could have in the diagram the point which corresponded to evolution of heat and that which corresponded to absorption of heat. The author had spoken of "arrests" and he (the speaker) did not think they were all arrests, some might be accelerations.

Dr. Rosenhain said the work in question was of an extraordinarily complicated nature. The idea of following the mazes of the relative behaviour of aluminium-silicide, copper-aluminium compound and aluminium at various temperatures and under various conditions of treatment was one which appealed to the author and which she took up at her own desire with a heroic disregard for the difficulties which were involved, and he thought she was to be congratulated upon having found what was at least an intelligible tract through the wilderness.

The results were interesting and important in themselves for two different reasons. In the first place there existed, what one was always sorry to see, although it was interesting from other points of view, a very distinct discrepancy in the results arrived at in regard to the cause of the age-hardening of duralumin, particularly between the workers at the National Physical Laboratory in England and their opposite numbers, as it were, the workers in the Bureau of Standards in America. The matter had been discussed between those two bodies, in fact, one of the gentlemen responsible for the work in America came and worked for a while in the National Physical Laboratory, and they were on the friendliest terms. All the more for that reason they were very glad to think that the discrepancy had now been cleared up, as he thought it undoubtedly had been cleared up, by Miss Gayler's paper. The view put forward by P. D. Merica and others, was largely that the hardening of duralumin arose from the precipitation from solid solution of the compound CuAl2, but in their work they did not consider the effect of magnesium and did not realise the existence of magnesium-silicide.

On the other hand, the work done by the National Physical Laboratory in connection with the Eleventh Alloys Research Report, mainly by Dr. Hanson and Miss Gayler, showed fairly conclusively that vigorous hardening was only possible with the compound Mg2Si, whose properties they discovered and investigated. As the paper showed, those two substances both played a part and interacted upon one another, but he thought it was still right to say that the principal part, the largest hardening effect, only occurred when the compound Mg2Si was present in the proper amount, and that it depended upon the behaviour of copper present at the same time.

The very interesting effect of prolonged heating and annealing at various temperatures in first producing a slight softening and then increasing hardening, was interesting and important. He took great pride in one result which the author showed quite casually—the fact that those rather disconcerting phenomena did not occur in the alloy "5"—4 copper, 2 nickel, 1½ magnesium—and consequently, one was relieved in that case from some of the anxieties which behaviour of that kind inevitably brought to one's mind when contemplating the use of one of those alloys in engines working at temperatures in the neighbourhood of 200 deg. C. The second line of interest in the paper arose from a point which was also present in Professor Edwards' mind, namely, that the whole of the work fitted in, and by fitting in, confirmed the views on hardening which had previously been enunciated. He protested most vigorously against Professor Edwards' reference to them as Jeffries' views. Jeffries was a personal friend of his (the speaker's) and would be the first to admit that those views were not original with him. But at all events those views were very strikingly confirmed by the author's work. He differed very strongly from Professor Edwards' remark that microscopic studies would lead nowhere. He thought they had led both Professor Edwards and the other members a very long way, and he thought Professor Edwards was a little ungrateful in speaking as he had done of those methods. He knew what Professor Edwards had in mind, and personally he quite agreed that when they could apply some more searching methods of examination, such as X-rays analyses, then further progress would be made.

Dr. Carpenter, referring to the author's own curves of alloys quenched from 500 deg. C. but not aged, it was stated under them that they were "deflections of differential galvanometer," and further on that they were "derived differential heating curves . . ." This point had to be made clear.

In replying briefly to the discussion, Miss Gayler said her views as to the cause of age-hardening at high temperatures were the views of Jeffries, the tendency for the precipitation of the two compounds CuAl2 and Mg2Si. She differed from Dr. Rosenhain and did not think microscopic examination would greatly help, but expected much from X-ray examination. She apologised for using the term "arrests," these were critical points and not arrests, there was absorption and not evolution of heat. The work had not been an easy one; she was very glad Dr. Rosenhain had been interested in it, and hoped he would allow her to continue it. She had seen it stated that Mr. Honda was going to publish a paper shortly on the subject, showing, if she remembered rightly, that the ageing of alloys was due to magnesium silicide and to the copper being precipitated; this bare outline of Mr. Honda's work differed from the results of American scientists and from those of her own work. In reply to Dr. Carpenter, she said she took differential curves and plotted them with the derived differentials.

The Oxide Method of Determining Aluminium.

The third paper taken was entitled "Experiments on the Oxide Method of Determining Aluminium." It was a report by Mr. J. E. Clennell to the Aluminium Corrosion Research Sub-Committee of the Institute. The object of the investigation it described was to find a direct method of determining aluminium in the presence of iron and other impurities. The phosphate method was rejected as the precipitates obtained showed varying proportions of alumina and phosphoric acid. The ammonia method of precipitating aluminium as hydroxide was rejected also owing to the difficulties of filtering and washing the precipitate and obtaining it free from impurities. By the method finally evolved, iron was practically

eliminated and other impurities reduced to a minimum.

Dr. Carpenter said the work originated following upon a request from the Air Ministry which was transferred to the Institute; it was found convenient to put the matter in the hands of the main Corrosion Research Committee and to form an Aluminium Corrosion Research Sub-Committee. The work was under the supervision of Dr. Bengough, who was assisted by Mr. Stuart and Mr. Clennell. A report by Mr. Stuart on the protection of aluminium and its alloys had been handed in to the Air Ministry and to other Government Departments. An interesting side of the problem was as to how aluminium corroded, and here one was up against a difficulty, the existence of a matter in the colloidal form. The salts of aluminium were gels. He hoped the author would be able to find out that the salts of aluminium did not possess the gel property. If he did, he would confer a boon on all who were interested in aluminium alloys.

Mr. F. S. J. Pile stated that he had found the phosphate method as exact as the oxide one; there was not much to choose between the results when the phosphate method was taken or when it was the oxide method that was worked to. The phosphate method was easier. Aluminium and zinc were two elements difficult to deal with. He thought there was a wide field in organic chemistry for aiding the solution of the problem, and he urged all universities to see whether there could not be used an organic compound which would do for aluminium what dimethylglyoxime had done for nickel. Organic chemistry might be in possession of such a compound, or if not, could find one.

Mr. Clennell, in replying, said the phosphate method had been resorted to in the research, but it had been abandoned, not without reluctance, since, with it, it was impossible to arrive at constant proportions of alumina and phosphoric acid.

The Copper-rich Aluminium-Copper Alloys.

The next paper was a contribution by Mr. D. Stockdale on "The Copper-Rich Aluminium-Copper Alloys," which is reprinted on page 396.

The structures of the alloys of copper having up to 20 per cent. of aluminium were examined by the author, who used the thermal data supplied by a study of the cooling curves and by quenching experiments in conjunction with microscopic examination to obtain the equilibrium diagram more exactly. He discredited the opinion that the addition of small quantities of aluminium to pure copper raised the freezing-point of that metal and showed that the minimum in the liquidus curve at 1,031 deg. C., with 8·3 per cent. of aluminium, was a true eutectic point. A small arrest point at 1,017 deg. C. with alloys containing 16·5 per cent. and 18 per cent. of aluminium had been discovered, but there was no indication of a minimum in the liquidus at about 16 per cent. Copper at 1,000 deg. C. could hold only 7·4 per cent. of aluminium in solid solution; at 500 deg. C. and lower temperatures it could hold 9·8 per cent., although to obtain such an alloy a long annealing was required. The beta solution broke down above 535 deg. C. The portion of the diagram concerning the beta and gamma field had been radically altered.

Professor C. A. Edwards, who opened the discussion, referred to the work done by Dr. Carpenter and himself, which was given in the eighth report to the Alloys Research Committee read before the Institution of Mechanical Engineers, in 1907.* That report covered a wide field, and if the diagram it contained were compared with the author's, it would be seen that the foundation had been worked out by Dr. Carpenter and himself. Broadly speaking, the conclusions of the author were as he (the speaker) would have anticipated. He asked whether the eutectic at 8·3 was correct, since it was not an easy matter to get instantaneous quenching in metals so complicated as these alloys. It would be interesting if very pure aluminium could be used to arrive at the exact situation of the eutectic point. Differences would be due to impurities. He was sorry the author had confined his researches to a somewhat limited range, and had he extended them to, say, 30 per cent. of aluminium he would have been able to put forward more new details. There was still a large amount of work to be done with alloys having, say, between 23 per cent. and 30 per cent. of aluminium, and he (the speaker) was convinced that Curry's diagram was not correct in that direction. He felt that there was an extremely useful future for the 8 per cent. copper aluminium alloys. He was glad the author had referred to a structure as twinned structure.

Dr. Carpenter also referred to the Eighth Alloys Report which represented the commencement of his connection with Professor Edwards. The author's paper was one of three which came from Mr. Heycock's laboratory, all of which were very substantial contributions. The author's micrographs of the beta alloys had not been surpassed or even equalled. He (the speaker) had seen the apparatus with which the author had taken his curves and found it an interesting development of Roberts Austen's methods; it had limits in regard to sensibility, but was a very useful apparatus. He (the speaker) had always been worried by Curry's statement to the effect that small quantities of aluminium raised the freezing-point of copper nearly to 1,100 deg., and noted that the author had not found that to be the case; this finding confirmed the Carpenter and Edwards curve. In regard to the falling liquidus he (the speaker) took it that not melting occurred but disassociation. In these alloys, the liquidus and solidus were so close that it was difficult to measure the latter. The author had stated that the portion of the diagram showing the existence of the gamma phase was almost entirely new; previous authors had prolonged the line Q O to the point H. The evidence in support of this he (the present author) added, was slight, but was not himself convinced that his conception of these areas was correct. Dr. Carpenter found that a very wise proviso. One of the author's statements, under C, was to the effect that the 16·5 per cent. alloy quenched from 980 deg. C. apparently consisted entirely of gamma; this, said Dr. Carpenter, was the beta plus gamma phase. Either the diagram was not correct at that point, or the rate of conversion was so rapid that the author could not stop it. In regard to Cu_4Al, the existence of that compound had been suggested in the Eighth Report, and he (the speaker) no longer held the view that that compound existed.

Dr. F. Johnson said the author had stated that the liquidus showed a maximum about 12·5 per cent. (Cu_3Al = 12·44 per cent.), though the alloys in the neighbourhood all froze at about the same temperature, 1,047 deg. C., and this was an indication that the compound formed, if any, was somewhat unstable. By this, the author appeared to have some doubt as to the point, but further on he had said that the beta phase had as its foundation the compound Cu_3Al which was capable of taking into solution either excess of copper or of aluminium; as to this he appeared to entertain no doubt. The author had also said that the 14 per cent. specimen when quenched at 850 deg. C. showed a very fine structure of gamma with traces of beta; but in his illustration (Fig. 19) the reverse was given; perhaps this was a printer's error. Mr. Johnson also asked whether his analyses were so correct as to justify his statement to the effect that his point M must lie slightly lower than 12 per cent., namely, at 11·9 per cent. of aluminium; this meant most accurate analyses to warrant a one-tenth of 1 per cent. difference. The paper, he added, would be found most valuable to all interested in these alloys and especially to the members engaged in teaching.

Professor Turner congratulated the author upon his most skilful researches. Professor Edwards had referred to the desirability of dealing also with the 7 per cent. to 10 per cent. aluminium alloys. Professor Turner added, in regard to this, that during the past session work had been done on these series at his Birmingham laboratory, covering the rate of cooling, annealing, tensile, density and other properties. The paper was actually written, but there was such a heavy programme already for the present meeting of the Institute at Swansea that it was not sent in; otherwise, the two papers could have been taken and discussed together. An opportunity would perhaps occur later, when the present author's (Mr. Stockdale's) criticisms would be valued.

Dr. Rosenhain said, he would like to take the present opportunity for adding a personal word of appreciation of the paper, emanating as it did from the laboratory of his very old friend, Mr. Heycock. One interesting point to which the author referred was worthy of a little more emphasis, namely, the striking similarity between the copper-aluminium and the copper-tin systems. The author referred to that in connection with the micro-structure particularly of the "coffin-shaped" crystals. The connection of the two systems went very much further than that. An enthusiastic member of the staff of the National Physical Laboratory had attempted to construct a complete model of the ternary system copper-aluminium-tin. A good deal of data was lacking for its completion, but when anyone saw that model even in the comparatively rudimentary state it had reached, one realised that the copper-tin diagram and the copper-aluminium diagram were apparently merely two sections of some sort of continuous surface at slightly different angles. There was a V-shaped depression in the middle which was reproduced in both, and which ran as a valley right across the ternary model. The whole thing suggested that the two diagrams were built on the same formula with a slight change of constants. He thought it might possibly mean that it was the germ of a very much larger generalisation. They might some day be able to write down a formula which would give the equilibrium diagram of any binary system by merely changing the constants. Those systems were definitely dependent upon certain quantitative relations between the elements involved, and when those relations were understood fully they would be able to verify them by one simple generalisation. The author had referred to the very vexed question of the nature of a solid solution, and adopted a view of Professor Edwards that a definite compound must be the basis of a solid solution. He confessed that only a year ago he would have subscribed to that view, but recent facts had convinced him that it was not tenable. The only fact upon which reliance could be placed was that each solid solution was based upon some special space-lattice which might be that of a pure metal or a compound, or might not. What exactly determined the nature of a space-lattice it was not possible to say. With reference to Professor Edwards agreeing with the author's statement in regard to the banded structure in the beta constituent as being twin crystals, he (the speaker) protested against that because he thought it was quite unjustified, and he did not think either Professor Edwards or Mr. Stockdale had the slightest ground for their assertion. With regard to the practical use of the alloys under discussion, the data for their use had been available since 1906. In the Eighth Report there was such a mass of facts concerning the actual physical and working properties of the aluminium bronzes that he was sorry they had not been used as extensively as they might have been. Incidentally they possessed the property of resisting corrosion under certain conditions in a marked way, and one would expect them to be permanent and lasting. He had seen a practical use of them where that property was conspicuously absent, however. He had been spending a few weeks in France, where they had been adopted for the coinage of the country. He was quite certain that under those conditions, their permanence in any one's possession was not great.

Sir Henry Fowler advocated a closer intercourse between the users of alloys and the investigators.

In the course of his reply, Mr. Stockdale thanked the meeting for the favourable way in which his contribution had been received. He did not think Professor Carpenter quite understood the beta gamma area in the diagram, Fig. 1, of the paper, embodying the results of all the experiments. As he (the speaker) understood it, it was important to quench any alloy between 15 per cent. and 18 per cent. or thereabouts from the beta plus gamma area, or even from the beta area itself and keep up any beta constituent. It all went over to the gamma constituent. He had perhaps rashly said that beta was Cu_3Al. At Cambridge they were taught that they could not call a thing a compound until it could be caught hold of, put in a bottle and labelled. One could not do that with the compound in

* See ENGINEERING, vol. lxxxiii, pages 108 *et seq.*

question, if it were a compound. He thought it better to withdraw there and simply say he did not know whether it was a compound or not. Regarding the microsection, Fig. 19, the dark parts were fairly large crystals of gamma. If the slide were looked at under a high magnification, nearly all the ground mass was found to consist of these dark crystals, and one might, or not, find traces of beta. The analyses of the alloys were carried out using the sodium thio-sulphate method. He had much difficulty at the start, until he found out that if he did not use any great excess of sodium thio-sulphate he could analyse one of these aluminium alloys three or four times and get consistent results within 0·05 per cent.; he was therefore justified in saying that the eutectic point, according to this piece of work, was less than 12 per cent. He agreed with Dr. Rosenhain in regard to the great similarity between copper-tin and copper-aluminium alloys.

The last paper for the Thursday morning meeting was on "The Cleaning of Aluminium Utensils." It was by Dr. R. Seligman and Mr. P. Williams, and in the absence of the authors, was taken as read.

(To be continued.)

INDUSTRIAL NOTES.

THE outstanding feature in the industrial situation is the closing down of the works of the Ebbw Vale Steel, Iron and Coal Company. The cause of the trouble which has arisen seems to be entirely due to the action taken by Mr. Evan Davies, the Member of Parliament for Ebbw Vale. Nor is the trouble of recent occurrence, since, according to a statement issued last Tuesday by the company, Mr. Davies wrote in January last to Mr. Hann, the general manager, saying that "his intention was to bring all work at a standstill in Ebbw Vale, both at the collieries and at the iron and steel works, adding that negotiations were useless, as no arguments would alter his decision." Later, Mr. Davies expressed regret at having so written, alleging that he was in very bad health; he asked that the letter be returned to him, this was done and the letter was destroyed. Towards the end of August, Mr. Davies stopped all the Ebbw Vale collieries, and instructed the coke-oven men to cease work, but under the pressure from the iron and steel workers he ordered the miners to return to work and the coke-oven men to continue at work. Sir Frederick Mills, the chairman, asked Mr. Davies to put his grievances before Mr. Hann, adding that these would be duly considered, and failing agreement recourse could be had to the Disputes Committee of the Conciliation Board. Mr. Davies met Mr. Hann once; he then broke off further negotiations and refused to follow the proper procedure for putting his case before the Disputes Committee, which consists of equal representation of the owners and men. It is added that for the last twelve months the Ebbw Vale collieries have been working on a temporary agreement pending the decision of an arbitration set up at the request of the men. The arbitrator, Professor Galloway, whose name was suggested by the men's representative, recently gave his award; this was not to the liking of Mr. Davies. The award comes into operation on November 1, and Mr. Davies expressed his intention of preventing its adoption by all means in his power, adding that the company must negotiate new terms with him. It is announced that the South Wales Miners' Federation have decided to take the negotiations in their own hands; they are said to have made arrangements for a deputation—which would not include Mr. Davies—to interview the directors of the works, and an offer they will put forward is stated to suggest working during three months under the conditions of Professor Galloway's award.

A meeting of the Executive Committee of the Miners' Federation was held in London at the close of last week, to consider the general wage situation throughout the coalfields. Seeing that twelve out of the thirteen districts in the Federation have a minimum wage, it was decided that the claim for a substantial improvement should be considered at the National Wages Board on October 5. At the same meeting, Mr. Frank Hodges stated that on behalf of the international miners in general and the British miners in particular, he had invited the permanent officials of the American Mine Workers' Union to come to Europe to consider plans for mutual assistance in the event of a miners' lock-out in any country.

In this connection, it is interesting to note from *The Times* that Sir Henry Barwell, the Premier of South Australia, moved in the Australian Parliament, the second reading of the Industrial Disputes Bill, adding that the Federal Arbitration Court was doomed, and that the passage of the Bill would hasten its end. The existing machinery was cumbersome, uneconomic, slow and costly, it bred strikes and the bitterest class hatred. Compulsion, Sir Henry further stated, was wholly against the employers, as the workers entered the court on the principle "tails I win; heads you lose." The Labour Party advocated the retention of the system, because their objective was social violence. The Bill proposed the abolition of the Arbitration Court and the substitution of a system of voluntary conciliation. The boast frequently made that the penalties under the Arbitration Acts could not be enforced against thousands of trade unionists because of insufficient accommodation in the gaols was, the Premier added, perfectly true.

In the first quarter of 1921, the last three months of control, the coal industry was worked at a loss amounting, according to the official returns of the Mines Department, to 14,684,936*l.* This was the position when the stoppage began on April 1. The cost of the stoppage to the collieries is given by the Mines Department as 10,413,650*l.*, which is probably an under-estimate, since the return did not quite cover the whole industry. When work began under the terms of settlement on July 1 the industry was, therefore, burdened with a loss, apart from the loss sustained during the control period, of something substantially in excess of 10,000,000*l.* To meet this serious position the colliery companies had to draw largely on their reserves, limitations of banking accommodation adding in many instances acute embarrassment to the situation. For the period April, 1921, to June, 1922, the industry was worked at a net loss of 1,328,962*l.* This loss should be compared with the profits of the industry for the last complete pre-war year, 1913, which amounted to 28,000,000*l.* If the twelve months July, 1921, to June, 1922, alone were taken, as against a profit of 2*s.* per ton in 1913, there was a profit in the first year of the new agreement of 10·1*d.* There are three wage rates in the collieries, the basis rate, the standard rate, and the actual wage paid which, under the terms of settlement, must be at least 20 per cent. higher than the standard wages. This 20 per cent. had done much to mitigate the ill-effects of trade stagnation upon the wages of mine workers, but it had also made large inroads into standard profits, and had in many instances not only absorbed the whole of them, but required cash contributions from the owners, involving heavy and, irrecoverable losses. From November, 1921, to the end of June, 1922, the sums paid by the owners in order to make wages up to 20 per cent. above the standard wage amounted to 2,980,143*l.*; standard profits, therefore, due to the owners under the form of settlement, were short by nearly 3,000,000*l.* for the eight months in question.

Dealing with the American coal strike, *Mining and Metallurgy*, New York, says that "with the aid and abbetal of their enemies by the politicians, the public lost the strike." The journal further states that at no time had there been any clear explanation to the public from any quarter whence a voice would command attention, telling that the economic wounds of the war were not healed, that it was time for patience, hard work and thrift, and that no classes of workers could expect to maintain their war scale of wages, which could be done only at the expense of other classes of workers. That the miners were able to hold out so long in idleness was evidence of the excessive amounts that they had been drawing out of the national dividend and an exposure of the futile talk about the grievous cost of living. The war will be resumed in 1923 or 1924, the journal adds; economic conditions will make that unavoidable.

Speaking last Tuesday in Sheffield, at the annual meeting of the Staveley Coal and Iron Company, Mr. C. Markham said the profits for the past year were 190,000*l.*, and the income-tax amounted to 186,000*l.* Besides that, they had to pay nearly 50,000*l.* in local taxation. Few people realised what taxation was to-day, and he was sure the working men did not. Another item under which they were groaning was railway rates, which were something almost beyond belief. In pre-war days, a ton of plates could be sent to Liverpool at a cost of 1*l.* 6*s.* 3*d.*; to-day, the cost was 2*l.* 7*s.*

A conference was held on Tuesday between the Negotiating Committee of the National Union of Railwaymen, representatives of other unions and of the railway companies, on the question of railway shopmen's wages, when an agreement was reached on the 10*s.* reduction per week, to take place on October 1, wages then to be stabilised to the end of the year; any future changes are only to take place by negotiation between the parties. Mr. Cramp stated that the settlement covered 75 per cent. of the men employed in railway shops in England and Wales, and that the 10*s.* reduction agreed upon compared with the 16*s.* 6*d.* reduction in the wages of men in the engineering and shipbuilding yards outside the railways. An agreement to the same effect, covering the case of the Scottish railways, was reached last week.

The annual meeting of Messrs. H. Briggs and Co., Limited, colliery owners, was recently held at Leeds, when it was stated that to-day in West Yorkshire the average daily wage of the collier was 16*s.* 10*d.*, compared with 9*s.* 3½*d.* in 1914. The average output per man per shift in 1914 was 21 cwt. To-day it was only 18½ cwt. The difference was mainly due to the working of the seven-hour day.

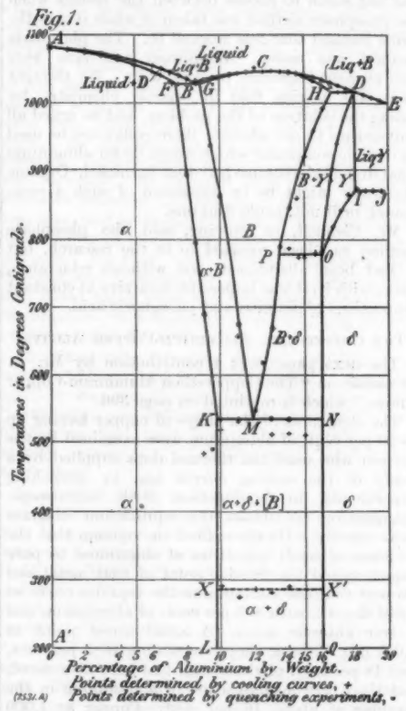
THE COPPER-RICH ALUMINIUM-COPPER ALLOYS.*

By DAVID STOCKDALE, B.A., Member (King's College, Cambridge).

THE equilibrium diagram of the copper-aluminium series has been investigated by numerous workers, and the most important papers on the subject are those by Carpenter and Edwards, Curry, Gwyer, Andrew, and Greenwood.

All these authors differ in their conclusions regarding certain details, notably the concentrations and temperatures at which transformations from one phase to another take place. In view of the probable future importance of these alloys, and of the great changes in their mechanical properties brought about by heat-treatment and small

Fig. 1.



(7532 A)

changes in composition, it seemed desirable that an attempt should be made to settle some of the doubtful points concerning the copper-rich alloys.

Two general methods of fixing the various points were used—the taking of cooling curves and the micro-examination of quenched specimens.

Apparatus.—All temperatures were measured by a platinum-platinum with 10 per cent. rhodium couple; a thin silica sheath was used when cooling curves were being taken, and the bare couple in the case of quenching experiments. In the latter, a millivoltmeter was used to measure the potential difference; in the former, a somewhat unusual recording apparatus.

The machine, simply, is a modification of that invented by Roberts-Austen. His apparatus consisted of a mirror galvanometer, which threw a spot of light on to a photographic plate, this plate being moved up, meantime, by clockwork, or by water which ran into a tank under constant pressure. The plates were expensive and were found clumsy in use, owing to the necessity for darkness. The recorders installed in this laboratory were designed by Heycock and exhibit most of the essential features of the plate recorder, but are much simplified by the fact that the beam of light falls on a thin sheet of paper. All the experimenter has to do is to follow this beam with a sharp-pointed pencil. With changes of temperature the light moves right and left, while the paper moves up at any required rate. Very sharp curves may be obtained.

In measuring the freezing points, the apparatus was adjusted in such a manner that 1 cm. of the paper represented 6 deg. C., allowing measurements to 1 deg. C., though the author does not claim, by any means, that his

* Abstract of paper read at the Swansea meeting of the Institute of Metals, September 21, 1922.

temperatures are measured to this degree of accuracy. He believes, however, that the differences between the freezing points of the alloys are nearly correct. The chief advantages of such a recorder are that it is capable of measuring very small changes in temperature, and that it can indicate clearly two points when these points lie very close together.

Preparation of Alloys.—The alloys were made under charcoal in salamander crucibles, by first melting most of the copper, then adding the aluminium, and finally the remainder of the copper. It was found that uniform alloys could be made much more easily by this method than by adding the aluminium to the whole of the molten copper.

On adding the aluminium there was always a great evolution of heat; on adding the second portion of copper there was generally no such evolution, except when there was much aluminium present. These facts seem to show an explanation could not be upheld. The incandescence is probably caused by the heat of formation of the compound, Cu_3Al (12·44 per cent. aluminium).

In the quenching experiments, a furnace of the Rosenhain type was used. It was of the ordinary pattern except that the water reservoir was mounted 2 ft. above the tube instead of below it, as is usually the case. This made for more efficient quenching. The length of the heated tube was 8 in., and the 5-gramme specimens used were placed in the centre, very close to the bead of the thermocouple. It is unlikely that the actual temperature of a specimen and that registered differed by more than 5 deg. C.

In general, the specimen was heated 200 deg. C. above the suspected transformation point, and allowed to cool slowly. In each case the alloy was allowed at least half an hour to cool through the last 10 deg. C. before quenching. When the limits of the a solid solution were

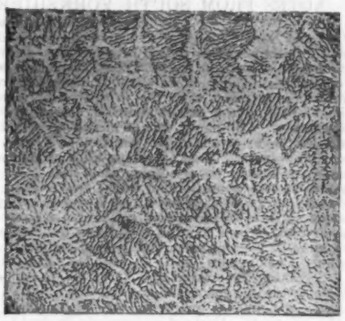


FIG. 2. 8·5 per cent. Al. Q. 1020 deg. C. × 45. Probably the remains of the $\alpha + \beta$ eutectic.

FIG. 3. 13·5 per cent Al. Q. 800 deg. C. × 45. Pure β.

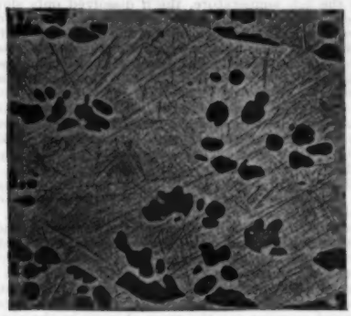


FIG. 4. 13·5 per cent. Al. Q. 790 deg. C. × 45. $\beta + \delta$.

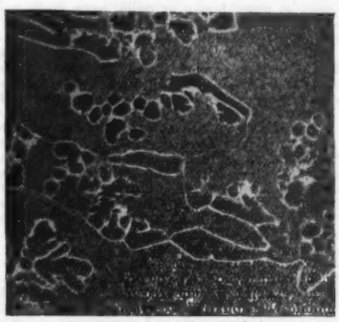


FIG. 5. 14 per cent. Al. Q. 840 deg. C. × 45. Large primary crystals of γ in fine ground mass of γ.

FIG. 6. 11 per cent. Al. Q. 535 deg. C. × 45. α + undecomposed β + patches of eutectoid (dark).

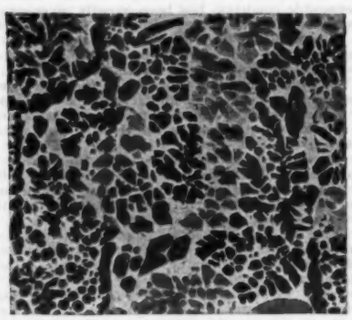


FIG. 7. 14 per cent. Al. Cooled in furnace. × 45. δ + eutectoid.

TABLE I.—*Points Found by Cooling Curves.*

Percentage of Aluminium.	Liquidus. Deg. C.	Solidus. Deg. C.	Other Points. Deg. C.		
0·0	1,085·0	—	—		
1·0	1,081·5	—	—		
2·0	1,078·0	1,077	—		
3·0	1,075·0	1,072	—		
4·0	1,069·5	1,063	—		
5·0	1,062·5	1,056	—		
6·0	1,055·0	1,049	—		
6·5	1,052·0	1,043	—		
7·0	1,047·0	1,032	—		
7·5	1,041·0	1,031 (s.)	—		
8·0	1,035·5	1,031(m.)	—		
8·5	1,034·0	1,031 (s.)	—		
9·0	1,035·0	1,033	485 (s.)	—	—
9·5	1,038·0	1,037	—	—	—
10·0	1,041·0	—	520 (s.)	290 (s.)	
10·5	1,043·0	—	—	—	—
11·0	1,045·0	—	657 (s.)	533 (l.)	274 (s.)
11·5	1,046·0	—	—	—	—
12·0	1,050·0	—	535 (l.)	286 (m.)	—
12·5	1,047·0	—	—	—	—
13·0	1,047·0	—	670 (m.)	513 (m.)	282 (m.)
13·5	1,046·5	—	—	—	—
14·0	1,045·5	—	788 (s.)	515 (m.)	290 (s.)
14·5	1,044·0	1,042	858 (l.)	744 (s.)	—
15·0	1,042·0	1,039	929(l.)	774(s.)	513(s.) 286(s.)
15·5	1,039·0	1,033	966 (l.)	780 (m.)	
16·0	1,035·0	1,031	994 (l.)	781 (m.)	—
16·5	1,032·0	1,015 (s.)	885 (m.)	816 (m.)	—
17·0	1,026·0	1,016 (s.)	950 (s.)	840 (m.)	—
17·5	1,022·0	1,017(m.)	863 (l.)	—	—
18·0	1,017·0	873	—	—	—
18·5	1,013·0	868	—	—	—
19·0	1,008·0	869	—	—	—
19·5	1,004·0	868	—	—	—

(s.) = Small heat evolution.
(m.) = Medium heat evolution.
(l.) = Large heat evolution.

decisively that the incandescence is not due to the formation of alumina from traces of oxygen contained in the copper; indeed, the heat evolution is so great that such

TABLE II.—*Points found by Quenching Experiments.*

Percentage of Aluminium.	Deg. C.	Deg. C.	Deg. C.	Deg. C.
8·0	900–880	—	—	—
8·5	800–790	—	—	—
9·0	700–680	—	—	—
9·5	500–480	940–930	—	—
10·0	—	870–860	—	540–530
11·0	—	680–670	—	540–535
12·0	—	—	Near 550	540–535
12·5	—	—	Near 620	—
13·0	—	—	Near 670	540–530
13·5	—	—	Near 790	—
14·0	—	—	850–840	540–530
15·0	—	—	—	540–530

being looked for, this period was more than doubled. The results of all the experiments are embodied in Fig. 1, and points found by cooling curves are recorded in Table I; by quenching experiments, in Table II.

The Liquidus, A, B, C, D, E.—This was determined by using 150-gramme specimens, cooling from 1,100 deg. to 800 deg. C. in 20 minutes. Various interesting points arise. First, Curry states that small quantities of aluminium raise the freezing point of copper nearly to 1,100 deg. No such occurrence was observed. Aluminium lowers the freezing point of copper, and the lowering is proportional to the concentration up to 3·5 per cent. of aluminium. If the ordinary laws for dilute solution hold in this case, the formula—

$$\frac{S}{100} \times \frac{T \times M}{W} = \frac{2T^2}{100L} \quad (L = 43)$$

shows that the molecular formula for aluminium in the copper is Al_{10}. At 3·5 per cent. there is a break in the liquidus, although it remains for a little a straight line, the slope of which indicates a formula Al_8. The freezing points obtained for dilute solutions are almost identical with those found by Heycock. The liquidus exhibits a minimum at 8·3 per cent. of aluminium and 1,031 deg. C. against 8 per cent. and 1,031 deg. C. found by Carpenter and Edwards, and 10 per cent. and 1,040 deg. C. found by Curry. It shows a maximum about 12·5 per cent. (Cu_3Al = 12·44 per cent.), though the alloys in the neighbourhood all freeze at about the same temperature, 1,047 deg. C. This is an indication that the compound formed, if any, is somewhat unstable. Although the experiments with alloys containing about 16 per cent. of aluminium were very carefully carried out and repeated, yet the minimum described by Andrew was not observed—indeed, up to 20 per cent. the liquidus appears to be a smooth curve, with, possibly, a small discontinuity about 17·5 per cent.

The Solidus, A, F, B, G, C, H, D, I, J.—As the solidus and the liquidus lie always very close together, it was quite impossible to fix the former line by quenching experiments. Its position is only roughly guessed at by the shape of the cooling curves, except in the case of the eutectic lines F G and H D. It is probable, however, that Curry places the liquidus and solidus too far apart. For example, he states that the 5 per cent. alloy freezes through a range of 24 deg. C. This seems to be much too large; 10 deg. C. is probably nearer the figure.

Some authors have recognised the existence of the eutectic line F B, but not the portion B G. Alloys of 7·5 per cent., 8 per cent. and 8·5 per cent. show an arrest at 1,031 deg. C. A photomicrograph of the 8·5 per cent. alloy quenched from 1,020 deg. C. is shown in Fig. 2. The structure is very peculiar, but is possibly the remains of a eutectic, the light α dissolving the dark β as the temperature falls. The alloys 10 per cent. to 14 per cent. of aluminium exhibit cooling curves typical of pure metals; in other words, the liquidus and solidus practically coincide. At 16·5 per cent. a second eutectic arrest makes its appearance at 1,017 deg. C. This is small in the case of this alloy, larger with the 17 per cent., and more than half the 17·5 per cent. alloy becomes solid at that temperature. The 18 per cent. alloy freezes near 1,017 deg. C., and like a pure metal, except that it shows a very small arrest at 873 deg. C. The existence of the line H D appears to be thus emphasised for the first time. Alloys over 18 per cent. of aluminium show an arrest at 868 deg. C., a temperature agreeing very well with that found by Andrew (874 deg. C.). As the solidus and liquidus for alloys containing less than 18 per cent. of aluminium lie so close together, the compositions of the first solid and the last to soildify cannot differ by more than 2 per cent. Quenching experiments have shown that diffusion in the solid state is very rapid at those high temperatures. Therefore, in making these alloys, no annealing is necessary in order to obtain a uniform solid, as in the case of high copper brasses.

Etching.—Ten per cent. ammonium persulphate solution in water gives the best results with alloys containing 11 per cent. or less aluminium, provided the specimens are first well cleaned by washing in alcohol. On the other hand, with the richer aluminium series the best results are obtained by using dilute ferric chloride in conjunction with dilute hydrochloric acid. The specimens shown in the photographs are etched in accordance with those recommendations.

There has been a discussion between Andrew and

Greenwood about the colour of the δ constituent. If the etching is carried out carefully and lightly this body appears of a beautiful blue colour. If the specimen is not very clean, or the etching is deep, it appears brown, or almost black. Often, too, it was noticed that the blue colour rapidly tarnished. After a day, the alloy appeared almost black. However, the blue colour could be again easily obtained by moistening the surface with alcohol and rubbing it with the finger. To give better contrasts for photographic purposes, the etching in the course of this work was generally deep, hence the δ constituent appears black.

The α Solid Solution.—This phase is represented by the area A F K L A′ in Fig. 1 (page 396). The position of the line F K was fixed entirely by quenching experiments. The points given by the 8 per cent., 8·5 per cent. and 9 per cent. alloys lie on a straight line, the 9·5 per cent. alloy point lay well off this line. It was assumed that this point also agreed with the others, but that at the low temperature, the β dissolved only slowly in the α, and that equilibrium had not been obtained during the comparatively short time the specimen had been annealing. This assumption is probably correct, because Greenwood obtained a 9·7 per cent. alloy as homogeneous α by annealing at 600 deg. C. for 20 days. The line K L could not be proved to be other than vertical.

Aluminium, then, is more soluble in copper at low than at high temperatures; at ordinary temperatures copper dissolves 9·8 per cent. by weight, at 1,030 deg. only 7·4 per cent. The α solution is especially remarkable for the ease with which it may be twinned.

The $\alpha + \beta$ Area.—The α and β phases occur together in the narrow range indicated by the area F G M K. This area is rather smaller than has been thought. The line G M was fixed by quenching experiments, and it is not quite straight, becoming more vertical with the higher percentages of aluminium. The 11 per cent. alloy, quenched at 680 deg. C., shows pure β, the twins being coarser than those of the 10 per cent. alloy and finer than those of the 12·5 per cent. alloy. It is here convenient to point out the great changes in the structure of the alloys caused by small changes in composition and small differences in heat-treatment; also that the ease with which these alloys can be obtained in a metastable condition has been greatly over-estimated. Except while fixing the positions of the lines F K and K N, no difficulty from this cause has been experienced; indeed, some difficulty in preserving the structures by quenching has arisen in certain cases.

When the α crystals appear from the β solution they possess the so-called "coffin" shape, a name applied by Heycock and Neville to α crystals appearing from the β solution of the copper-tin series. The similarity between some of these photographs and those taken by the above workers of the copper-tin series is most remarkable. For example, the structures exhibited by the 10 per cent. by weight copper-aluminium alloy are closely paralleled by those exhibited by the 14 atomic per cent. copper-tin alloy.

The β Phase.—This phase has as its foundation the compound Cu_3Al, which is capable of taking into solution either excess of copper or of aluminium. In no case was an untwinned solid solution obtained, the alloys generally exhibiting a martensitic or very coarsely twinned structure. Photographs show how the size of the twins greatly increases as the percentage of aluminium also increases. Big stresses are evidently set up by quenching. The alloys reply to these stresses in two ways: either they twin violently, or they break down to give another constituent. For example, the 14 per cent. specimen when quenched at 850 deg. C. shows a very fine structure of γ with traces of β. This phenomena was observed several times and evidently the γ was formed during the sudden cooling, because if quenched from below the line P H well-formed γ crystals are seen (Fig. 5), together with the fine γ, though surrounding the larger crystals are small areas of untwinned β. If the 14 per cent. alloy is quenched from 900 deg. C. it shows very coarse twinning.

Carpenter and Edwards claim that the compound Cu_4Al exists. Little evidence has emerged in support of this opinion, and certainly this body does not appear to form the base of a solid solution. Some crystals of the α solid solution are certainly darker than others. However, etching agents are usually very delicate in their operation, and it may well be that these darker crystals contain only a very slightly higher percentage of aluminium than the rest.

The γ Phase.—The portion of the diagram showing the existence of the phase is almost entirely new. Previous authors have prolonged the line Q O to the point H. The evidence in support of this is slight, but the present writer is not himself entirely convinced that his conception of these areas is correct. The difficulties in the way of obtaining definite proofs are great. The high temperature, the impossibility of preventing the β breaking down to the γ on quenching, the brittleness of the alloys, and the presence of blowholes in the specimens, are a few. His evidence is given below: (*a*) There is no doubt about the existence of the line H D, the eutectic arrests being the greater the nearer to the point D. (*b*) The 16·5 per cent. alloy shows a fairly definite arrest point at 885 deg. C. The 17 per cent. alloy shows a very small one at 950 deg. C. This latter would have been entirely missed, if not looked for specifically. (*c*) The 16·5 per cent. alloy quenched from 980 deg. C. apparently consists entirely of γ, but there are many very small crystals present. These are found chiefly in bands, presumably round the primary γ crystals. The slow-cooled alloy is a uniform solid solution, showing only large crystals. If the quenched and unquenched alloys are etched in very dilute ferric chloride and hydrochloric acid solution under exactly similar conditions, the unquenched specimen remains polished when the quenched has developed a pattern. (*d*) The quenched specimen possesses a slightly reddish tinge, possibly through the presence of β, while the unquenched specimen is silvery-white. The existence of the line I O, found by several authors, has been verified, and Andrew's observation of the line P O has received corroboration. The two sets of results are in close agreement, as is shown in Table III.

TABLE III.

Percentage of Aluminium.	Andrew.	Author.
	deg. C.	deg. C.
13·5	766	—
14·0	766	768
14·5	—	774
15·0	—	774
15·5	766	780
16·0	766, 780	781
16·5	809	816
17·0	847, 839	840
17·5	—	863
18·0	868, 874	873
18·5	—	868
19·0	874	869

The arrest point is very small in the case of the 14 per cent. alloy, and increases with increasing aluminium content. Presumably Andrew's explanation that it is a change in the γ body is correct. As before, no change in the solution after the crossing of the lines P O and O I could be discovered by etching agents.

What is the γ solid solution? According to the theory of Edwards, all solid solutions must have as their foundation an element or a compound. Copper gives the α solid solution; the compound Cu_3Al the β. The existence of the compound CuAl is accepted, but this body gives rise to an entirely different series of solid solutions. The writer believes that the base of the γ is the compound Cu_2Al (17·6 per cent. aluminium). In presence of an excess of copper or of Cu_3Al, this undergoes some form of allotropic change, giving rise to the δ series of solid solutions.

The $\beta + \delta$ Area.—Two of the photographs which fix the position of the line M P are given (Figs. 3 and 4). This area calls for no remark when once the great change in structure obtained by small changes in heat-treatment is pointed out.

There has always been a tendency to place the point M at about 12·4 per cent. of aluminium. This is clearly wrong, as an alloy containing 12 per cent. if annealed for an hour at 540 deg., consists of pure β with several well-formed crystals of δ. Thus the point M must lie slightly lower than 12 per cent., say, at 11·9 per cent.

The Line K M N.—Of all the lines in the diagram, this is the most disputed. Carpenter and Edwards placed it at 530 deg. C., Curry at 566 deg. C., and Andrew at 515 deg. C. These authors found double points on the cooling curves of several of the alloys, the second generally occurring about 480 deg. C.

In these experiments the mass of alloy used was 150 grammes, and it was cooled at the rate of 10 deg. C. per minute. No double point was found, though the evolution of heat came very irregularly. It is interesting to note that it appeared with the 9 per cent. alloy. Evidently this rate of cooling is too quick to enable the α to take up all the β into solution, and the undissolved β breaks down as usual.

Quenching methods were then applied. The alloys 10 per cent. to 15 per cent. were annealed for 2 hours at 540 deg. C. and then quenched. Not one showed a trace of eutectoid. After similar treatment at 530 deg. C., every specimen showed eutectoid structures, as in Fig. 6. The 11 per cent. and 12 per cent. alloys were annealed for 1 hour at 535 deg. C. and quenched. The results were fortunate. The 11 per cent. specimen showed well-developed α, much unchanged β, and several patches of eutectoid; the 12 per cent. showed many well-defined crystals of δ, much unchanged β, and a few beautiful patches of eutectoid.

The position of the line K M N is evidently near 537 deg. C. In the case of alloys containing between 10 per cent. and 16 per cent. of aluminium, the small arrest point at 286 deg. was always noted. This increases up to 12 per cent. and then decreases. Though little work was carried out, nothing was found to upset Andrew's explanation that these points are caused by the final disappearance of the β constituent, which has existed down to this temperature in a metastable condition. It was thought that these alloys might possibly possess marked magnetic properties, but experiment showed that this was not the case.

TABLE IV.

Intended Composition. Aluminium per Cent.	Aluminium per Cent.	Copper per Cent.	Iron per Cent.	Silicon per Cent.	Totals.
8·0	7·92	92·03	0·007	0·07	100·03
9·0	9·07	90·90	trace	0·11	100·08
10·0	9·94	90·00	trace	0·08	100·02
11·0	10·96	—	—	0·10	—
12·0	11·99	—	—	0·09	—
12·5	12·53	—	—	0·09	—
13·0	12·86	—	—	—	—
13·5	13·54	—	—	—	—
15·0	15·09	—	—	—	—

Photographs of alloys slowly cooled in the furnace were taken, one of which is reproduced in Fig. 7. The structures of the 8½per cent. and 9 per cent. alloys are similar to that of the 7 per cent. alloy.

Analysis of Alloys.—It is always difficult to analyse an alloy containing a great excess of one constituent, or to analyse any aluminium alloy accurately. Analyses were carried out on specimens which had undergone heat-treatment, and the results obtained showed that the synthetic composition was very approximately achieved. Andrew arrived at similar results. Each specimen contained rather less than a tenth of 1 per cent. of silicon, with a trace of iron (0·007 per cent. in one case, estimated electrometrically). Table IV gives the results.

In conclusion, the writer wishes to offer more than the customary thanks to Mr. C. T. Heycock, M.A., F.R.S., for his ever-ready advice and hearty encouragement. He wishes also to acknowledge his indebtedness to the Department of Scientific and Industrial Research, who made it possible for him to carry out this work.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Irregular movement in raw and semi-finished materials is attributed principally to the uneven distribution of foreign trade. Thus the latest revision of official quotations shows that all classes of iron are diminishing in price with the exception of hematites, which, following the export demand, have appreciated considerably. Compared with a month ago East Coast hematites have advanced 8*s.* per ton and West Coast mixed numbers 5*s.* East Coast qualities usually occupy a lower level than those coming from the West Coast, but the current quotation for both, delivered at South Yorkshire works, is 5*l.* 5*s.* to 5*l.* 10*s.* Business in forge and foundry sorts is still far from brisk, and makers in the Lincolnshire district have now reduced quotations to a level more in keeping with the general condition of the market. Lincolnshire No. 3 foundry has declined 2*s.* 6*d.*, making the current rate 4*l.* 2*s.* 6*d.* to 4*l.* 5*s.*, and Lincolnshire forge has been marked down by an equal amount, the official price in the latter case being 3*l.* 17*s.* 6*d.* to 4*l.* Derbyshire ironmasters decline to go below the level reached in April last, their quotations standing at 4*l.* 2*s.* 6*d.* for No. 3 foundry, and 3*l.* 17*s.* 6*d.* for forge qualities. Bar makers, in the hope of improving the state of order books at mills, have made a further cut of 10*s.* per ton, making the quotation 11*l.* 10*s.* to 12*l.* Sheets have also declined 1*l.* as compared with a month ago, the price now being 15*l.* to 16*l.* delivered at local works. The improvement already reported in basic steel, which is more than maintained, has been followed by greater activity at rolling mills, some of which, for the first time this year, have worked a full fortnight. Orders which are helped considerably by French requirements, are so insignificant that they would escape comment under normal conditions, while the variety of sizes asked for involves the repeated changing of rolls, accompanied by a corresponding increase in production cost. Rolling-mill masters, however, are so anxious to relieve standing charges, that they willingly accept anything in the way of new business. Makers of alloy steels for the automobile trade, and of tool steels, are somewhat better employed, though instances are easy to find of old-established firms who have the greatest difficulty to cover overhead expenses. The recent reduction in finished automobiles has put a better aspect on prospects, but makers of machinery parts and castings do not expect to benefit considerably until towards the end of November. In high speed and special steels, trade with America has undergone a marked slump. The increase in the United States tariff from 15 per cent. to between 46 per cent. and 47 per cent. has killed all inquiries. Firms who principally relied on American trade are feeling the effect acutely, but are comforting themselves with the belief that the tariff, being, as they consider, largely a political measure, cannot survive the next presidential election. In the lighter section the demand for files and rasps shows an upward movement, following the recent improvement in hand and circular saws. Some of the smaller firms devoted exclusively to the production of hand tools report that bookings for shoe rasps over the past fortnight exceed those for any two months during the year.

South Yorkshire Coal Trade.—Improved business with the Continent is more than maintained. Collieries are disposing of the whole of their output of best steams at firm rates, and are considering the question of increased production. At the same time the export boom to America has not brought substantial benefit to South Yorkshire and Derbyshire. Colliery owners complain with some bitterness of the maintenance of high transport rates to Immingham. Compared with competing districts, they are penalised to the extent of 3*s.* per ton, the average cost of carriage from this area working out at 6*s.* 9*d.* Efforts are being continued to induce the railway companies to grant more favourable terms on shipping account. Contracts for deliveries up to and including December have been arranged with some of the principal home railways on the basis of 20*s.* per ton for best South Yorkshire hards, and 1*s.* per ton less for Derbyshire and Nottinghamshire qualities. Secondary grades of steams are still being offered on the house-coal market, but find few buyers. The demand is chiefly for best qualities of house coal for winter stocking purposes. Best slacks are in strong request for coking purposes, but collieries are faced with a fresh accumulation of smalls. Remunerative prices, reaching as much as 25*s.* at ovens, are being obtained for blast-furnace coke for shipment. Quotations:—Best branch hand-picked, 36*s.* to 37*s.*; Barnsley best Silkstone, 33*s.* to 34*s.*; Derbyshire best brights, 24*s.* to 25*s.*; Derbyshire best house, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 19*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 19*s.* to 21*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market is steady and firm. American inquiries are still circulating, but there is a growing belief that demand on behalf of the United States is not likely to continue very much longer. Sales for Atlantic shipment—including several descriptions of iron—are reported to exceed 50,000 tons. Some of this has already been despatched, but tonnage is stated to have been arranged for some 30,000 tons yet to load. No. 4 forge iron is fairly plentiful, but all other Cleveland qualities are extremely scarce, and No. 3 is now hardly purchasable for delivery before November. The f.o.t. makers' works, and f.o.b. Tees quotations stand:—No. 1 and siliceous, 97*s.* 6*d.*; No. 3 G.M.B., 95*s.*; No. 4 foundry, 90*s.*; and No. 4 forge, 85*s.*

Hematite.—The hematite position has been slightly strengthened by recent sales. One or two makers are understood to have cleared their stocks and to have disposed of output a little way ahead, and these firms taking quite a strong stand, name 90*s.* as the minimum home and export figure for Nos. 1, 2 and 3 East Coast brands. Other producers still carrying considerable stocks are keen to secure contracts, and are prepared to accept less than the foregoing quotation. No. 1 hematite is put at 6*d.* above mixed Nos.

Foreign Ore.—Transactions in imported ore continue few and small, sellers' price concessions failing to tempt consumers, all of whom are understood to have good supplies, and to consider it advisable to still pursue a waiting policy. Best rubio is offered at 24*s.* c.i.f. Tees; and good Mediterranean ores are in the neighbourhood of 22*s.* 6*d.* c.i.f. Tees.

Furnace Coke.—Durham blast-furnace coke prices continue irregular. As sellers can readily dispose of supplies for shipment they show marked disinclination to accept the general offer of 26*s.* 6*d.* delivered made by local users for medium qualities, and ask up to 27*s.* 6*d.*

Manufactured Iron and Steel.—Some improvement is noticeable in one or two departments of manufactured iron and steel notwithstanding continued keen Continental competition. Inquiries are better, and a few more contracts for constructional material have been arranged, whilst one or two small orders for steel rails are stated to have been obtained. Quotations depend on destinations. In the home trade cost of conveyance over long distances is added to prices for local delivery, which stand:—Common iron bars, 10*l.* 10*s.*; iron angles, 11*l.*; iron rivets, 11*l.* 10*s.*; steel bars, 9*l.*; steel billets (medium), 7*l.* 10*s.*; steel billets (hard), 8*l.* 5*s.*; steel joists, 9*l.* 10*s.*; steel tees, 10*l.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.*; steel angles, 8*l.* 10*s.*; heavy steel rails, 9*l.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.*; and galvanised corrugated sheets, 16*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A serious situation has arisen at the town of Ebbw Vale as a result of a decision by the directors of the Ebbw Vale Steel and Iron and Coal Company, to close down immediately and for an indefinite period the collieries and iron works. This decision has thrown idle something like 12,000 men. The catastrophe, for such it is to the workers, has been brought about by the rejection of an arbitration award, which was to come into operation on November 1 next, under which irregular allowances were disallowed at the company's collieries. The directors' drastic step was, however, taken in view of the fact that during the past eighteen months frequent stoppages have taken place at the collieries, and that only recently on two occasions the men have absented themselves from work without notice. This the company state is an intolerable position, hence the reason for closing down. In August shipments of coal from the Bristol Channel to North America amounted to 518,000 tons, compared with 66,000 tons in July. The daily returns show that 572,148 tons of Welsh coal were exported to North America, of which 63,282 tons went to Canada and 508,866 tons to the United States. Of the total 319,158 tons were despatched from Cardiff, 197,685 tons from Newport, 28,410 tons from Swansea and 26,895 tons from Port Talbot. Last week 578,126 tons of coal were despatched abroad from South Wales, of which 126,661 tons, or 21 per cent. of the total went to America in 23 cargoes, 15 of 97,881 tons going to the United States and 8 of 28,780 tons to Canada. This brings the total to date to 188 cargoes of 1,122,375 tons, but as 203 steamers to carry 1,476,750 tons have been fixed a large quantity of Welsh coal is still to be shipped to America. Furthermore, fresh inquiries are circulating for dry large coals for shipment to Canada before the end of November and also cargoes for export to America. Last week 11 steamers of 27,125 net tons were "entered outwards" for America by the South Wales Customs. Meanwhile though actual prices are unaltered on the coal market a steadier tone is in evidence and business more active. There is an inquiry for 30,000 tons to 60,000 tons of large drys for shipment to Montreal by the end of November, 25,000 tons for shipment to Italy over the next three months, and for 10,000 tons to 20,000 tons of locomotive coal for export to Holland in October. Best dry large coal is firm at 28*s.* with best Admiralties from 26*s.* to 26*s.* 6*d.*, second from 25*s.* to 26*s.*, and Monmouthshires 23*s.* to 25*s.* Smalls of all classes are weak on the basis of 16*s.* for best steams down to 10*s.* for drys and 7*s.* 6*d.* for duff.

Iron and Steel.—Exports of iron and steel goods from South Wales last week amounted to 17,974 tons, compared with 3,233 tons in the previous week and 16,566 tons a fortnight ago. Of last week's total black plates amounted to 1,833 tons, tin plates 6,704 tons, galvanised sheets 2,697 tons and iron and steel to 6,740 tons. Black plates were sent to Brisbane and tin plates to Valparaiso and Montreal, besides parcels to Scandinavia, France and Holland.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The past week has not been responsible for any improvement in the steel-makers' position, and things are very much as they were. The few shipbuilding orders recently placed have certainly given one or two of the works a little more to do, but the amount is really of little importance owing to the capacity of the works, and only a steady flow of new contracts will help to improve the situation. The demand for sectional material continues fair, but there seems little prospect of expansion in the meantime. Makers of black sheets have few home orders, and the main source of employment is on thin sheets for export, the heavier gauges not being in demand at the present time. The general export trade is not of any great consequence, and there is very keen competition for any business on offer. Prices are nominally unchanged, but good lines receive very favourable quotations. The following may be taken as to-day's prices:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, ½ in., 10*l.* 5*s.* per ton—all delivered Glasgow stations.

Malleable Iron Trade.—The conditions in the malleable iron trade of the West of Scotland show no change, and the difficulty in keeping plant employed is becoming very serious. Orders are very scarce, and to secure any business keen cuts are being made. The price quoted for "crown" bars is 10*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—The state of the Scottish pig-iron trade continues good, and all surplus stocks of foundry iron have been cleared out. The demand from America has been very acceptable and there are still a fair number of orders to complete. There has been a falling-off in the forward commitments, but dealing in prompt lots is still very good, and so long as the position on the other side remains so unsettled the local producers are expecting a fair turn of business. Hematite iron is slow of sale, but shows signs of getting a little better. At present there are three furnaces turning out hematite, and 23 on foundry grades. Quotations are firm and are as follows:—Hematite, 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry No. 1, 5*l.* 5*s.* per ton; and No. 3, 5*l.* per ton, at makers' works.

THE INSTITUTION OF SANITARY ENGINEERS.—The opening sessional meeting of this Institution is to be held at Caxton Hall, Caxton-street, Westminster, S.W. 1, on Wednesday, October 4.

WHITWORTH SCHOLARSHIPS AND EXHIBITIONS.—The Board of Education has issued list 152, giving the names of the candidates in the recent competition, four of whom have obtained scholarships and 22 exhibitions, out of 53 competitors.

IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that our production of pig-iron in August was 411,700 tons, or 12,600 tons more than in July. The furnaces in blast at the end of the month numbered 126, or nine more than a month previously. This production is less than half of the pre-war average monthly output; in 1913 this amounted to 855,000 tons. The output of steel castings amounted to 520,800 tons in August, compared with 473,100 tons in July, while in 1913 the monthly output averaged 638,600 tons, and in 1920 it was as high as 755,600 tons.

THE INSTITUTION OF BRITISH FOUNDRYMEN.—A visit has been arranged to the works of the National Gas Engine Company, Limited, Ashton-under-Lyne, for Saturday, the 30th inst. The first meeting of the session Lancashire Branch, Burnley Section, is to be held on Tuesday, October 3, at 7.15 p.m. in the Technical College, Ormerod-road, Burnley, when Mr. J. Hogg will deliver his presidential address. The first meeting of the session of the Lancashire Branch will be held in the College of Technology, Sackville-street, Manchester, on Saturday, October 7, at 4 p.m., when Mr. John Haigh will deliver his presidential address and read a paper on "The Handling of Foundry Materials."

THE INSTITUTION OF PRODUCTION ENGINEERS.—Mr. Max. R. Lawrence, works manager of the Sterling Telephone and Electric Company, has been re-elected president of the above Institution for the 1922–23 session. Mr. W. E. Fisher and Mr. H. E. Honer have been elected as vice-presidents. The president's address will be delivered in October, and during the session the following paper will be read. "Standardisation," "The Production Engineer," "The Principles of Organisation and Management," "Machine Moulding Methods," "Modern Gauging Systems," and "Tooling for Production." Local branches of the Institution have been formed at Coventry and Newark-on-Trent, and it is hoped to form a section at Glasgow shortly. The annual business meeting of the Coventry branch will be held on October 3, while during the session the following papers will be read: "Sound Value in Machinery," "Publicity and Production," "Five Methods of Production," "Economical Production," "The Heat Treatment of Automobile Steels," "Electricity and Production," "Ball and Roller Bearing Manufacture."

NOTICES OF MEETINGS.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 2, Meeting in the Hall of the Bradford Technical College, at 7.30 p.m. Inaugural Address on "The Development of Public Electricity Supply," by the President (Mr. C. E. Allsopp, A.M.I.E.E.).

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, October 2, at 7.30 p.m., in the Watt Room of the Engineers' Club, Coventry-street, London, W., a paper will be read by Mr. J. W. W. Dyer, M.Sc., A.I.C., on "Rubber as it Applies to Air Craft."

THE INSTITUTE OF TRANSPORT.—Monday, October 2, at 5.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Third Annual General Meeting. Presidential Address by Sir Sam Fay.

THE CERAMIC SOCIETY, REFRACTORY MATERIALS SECTION.—Eleventh Annual Meeting, Birmingham, October 3 and 4. For programme see page 365 of last issue.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—Wednesday, October 4, at 3 p.m., at the Institution of Electrical Engineers, Victoria Embankment, London, a paper will be read by Mr. T. S. Lascelles on "Weissenbruch's Signal System on the Belgian State Railways."

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, October 5, at 5.30 p.m., at the Royal United Service Institution, Whitehall, S.W. Presentation of Awards. "The Work of S. P. Langley," by Professor L. Bairstow.

FOUNDRY CONGRESS AT NANCY.—The Association Technique de Fonderie de France is to hold its second congress at Nancy, from October 5 to 8. The first was held in Paris in 1913. It is announced that Belgian, American, British and Italian visitors are to take part in the proceedings.

CITY AND GUILDS OF LONDON INSTITUTE.—This Institute has now issued, for the Department of Technology, 29, Roland Gardens, South Kensington, S.W. 7, the programme for the session 1922–23. Inquiries are to be addressed as above to the Superintendent of the Department.

PERSONAL.—Messrs. Automatic and Electric Furnaces, Limited, of 281 to 283, Gray's Inn-road, London, W.C. 1, announce that on the 29th inst. they will move to 173 to 175, Farringdon-street, London, E.C. 1. Increased manufacturing facilities will be available at the new address, as well as new furnace demonstration rooms.

LANTERN SLIDES.—Messrs. Bellies and Morcom, Limited, Ledsam-street Works, Birmingham, inform us that they have the following sets of lantern slides, each consisting of 20 slides with a booklet of descriptive matter, which they will be pleased to supply on loan free of charge for lecture purposes: (1) Quick-Revolution Engines with Forced Lubrication, and (2) The Production of Power at Low Cost in Conjunction with Heating and Drying by Exhaust Steam.

INSTITUTION OF CHEMICAL ENGINEERS.—The thirteenth meeting of the Provisional Committee of the above Institution was held on Wednesday, 20th inst. The solicitors announced receipt from the Board of Trade of a letter stating that "The application for a licence to register the Institution under the provisions of Section 20 of the Companies' (Consolidation) Act, 1908, had now been entertained." The secretary reported that over 180 applications for membership had been received, and that the Selection Committee had considered a large number of these applications, and recommended that the names of the gentlemen selected by the Selection Committee, in the first instance be brought before the first council as soon as formed.

RUSSIAN SCRAP IRON AND STEEL.—Owned jointly by the Soviet Government and a German combine, a German-Russian company called Deutsche-Russische Metall-Gesellschaft, or "Derumetall," has been formed to collect, purchase and utilise the immense quantities of scrap iron in Russia, says *The Iron Age*, New York. Several shipments have already been made to Germany. It is estimated that there are in Russia over 3,000,000 tons of scrap, of which nearly 500,000 tons are in Petrograd, and 200,000 tons at the Black Sea ports. The company will, for the moment, deal only with the latter, as the cost of bringing the scrap from the interior would be too high to leave a profit. From these easily accessible supplies the Soviet Government, it is estimated, will receive about 10,000,000 gold roubles (1,000,000*l.* or 4,865,000 dols.).

SHIP FUMIGATION.—Messrs. Siebe, Gorman and Co., Limited, state that the motor yacht Ara, owned by Mr. W. K. Vanderbilt, was fumigated by them on Sunday, the 17th inst., with hydrocyanic gas in accordance with the United States Government Regulations. The whole of the fumigation was completed within 7 hours from the time of firing the charges until the ship was certified by the Port sanitary authorities as clear of poison gas. The "Proto" self-contained breathing apparatus was exclusively used for the purpose. A large number of workmen employed on board were able to continue work until their usual leaving off time. The fumigating party then commenced operations, and the ship was made clear of gas before the workmen returned; thus no time was lost either to the firm or the workmen. The furniture, tapestries, decorations, or fittings, which were not removed, were found in perfect condition on completion of the work.

THE SENNAR DAM ON THE BLUE NILE.

(*For Description, see page* 404.)

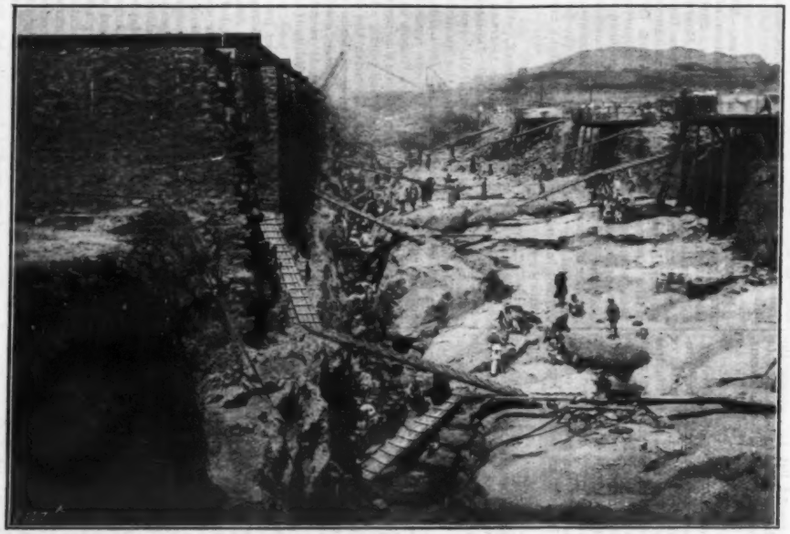


Fig. 1. View of Excavation to Sound Rock, showing Cut off Trench.

Fig. 2. Cut off Trench on Upstream Face filled with Masonry.

Fig. 3. Work at a Point where Rock fell away down Stream.

Fig. 4. Downstream Face; End of 1920-21 Season.

(To face page 386.)

THE CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; MAIN TURBINES.

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, GLASGOW.

(For Description, see Page 385.)

Fig. 43.

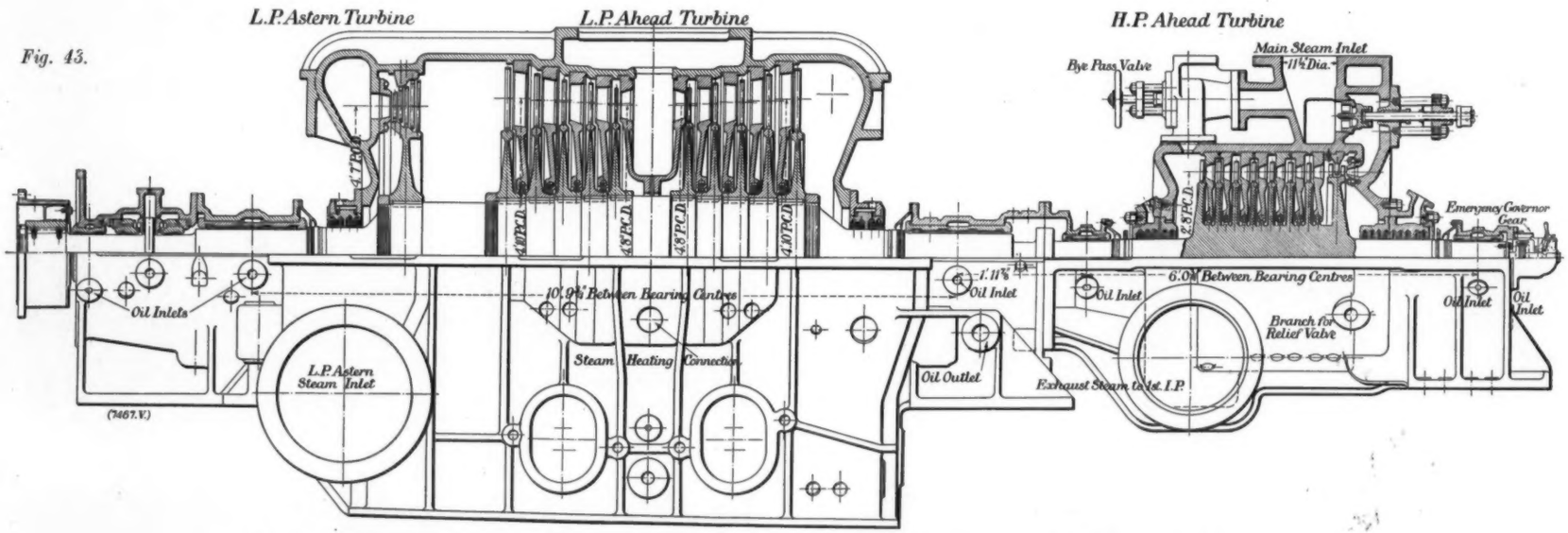


FIG. 43. LONGITUDINAL SECTION OF HIGH-PRESSURE AND LOW-PRESSURE AHEAD TURBINES AND OF LOW-PRESSURE ASTERN TURBINE.

Fig. 44.

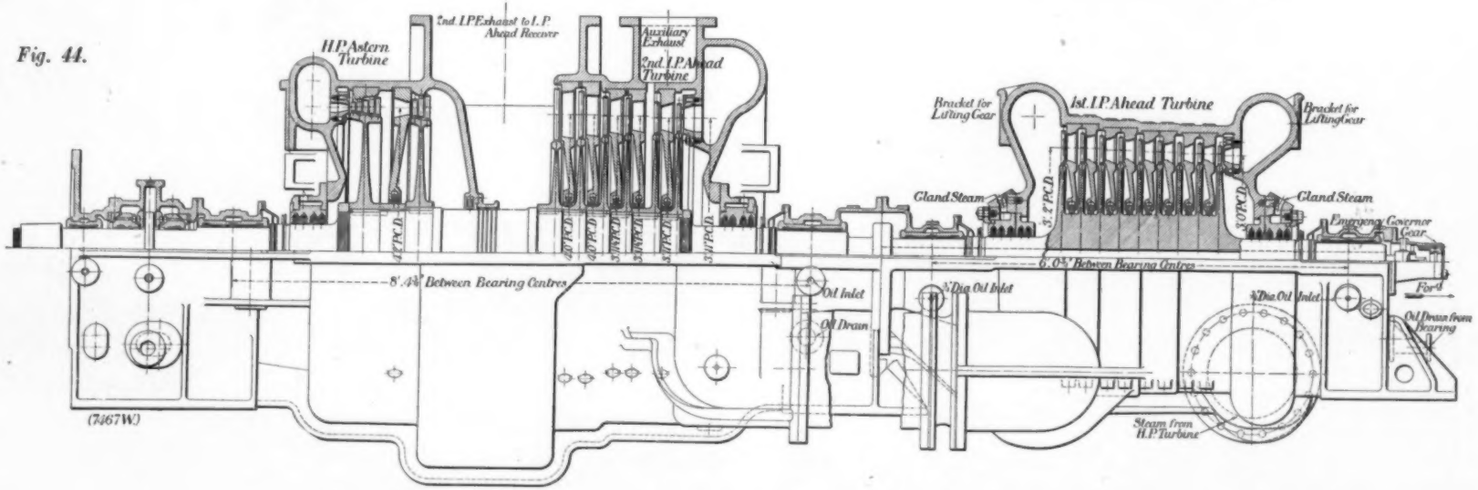


FIG. 44. LONGITUDINAL SECTION OF FIRST AND SECOND INTERMEDIATE-PRESSURE AHEAD TURBINES AND OF HIGH-PRESSURE ASTERN TURBINE.

CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; MAIN TURBINES.

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(*For Description, see Page* 385.)

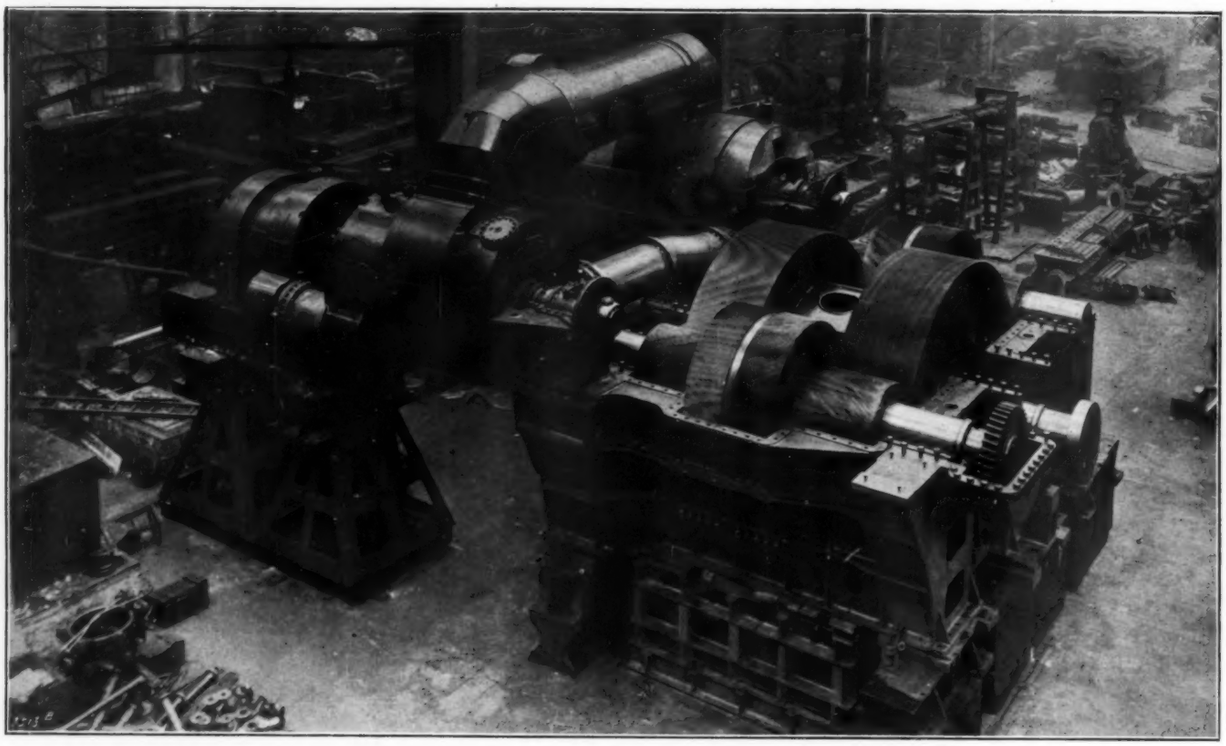

FIG. 45. STARBOARD PROPELLING UNIT DURING ERECTION, WITH GEAR-CASING REMOVED.

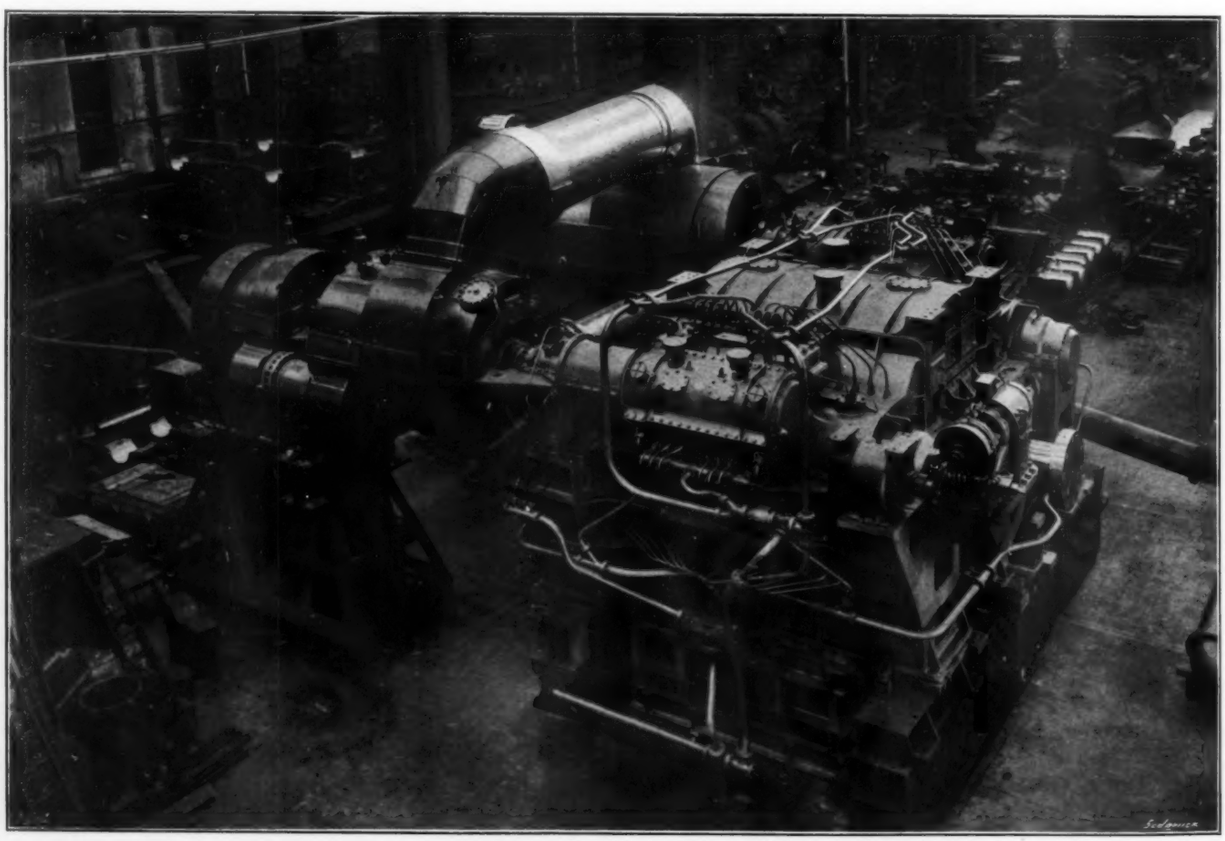

FIG. 46. COMPLETE STARBOARD PROPELLING UNIT FROM INBOARD SIDE.

CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; MAIN TURBINES.

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, GLASGOW.

(*For Description, see Page* 385.)

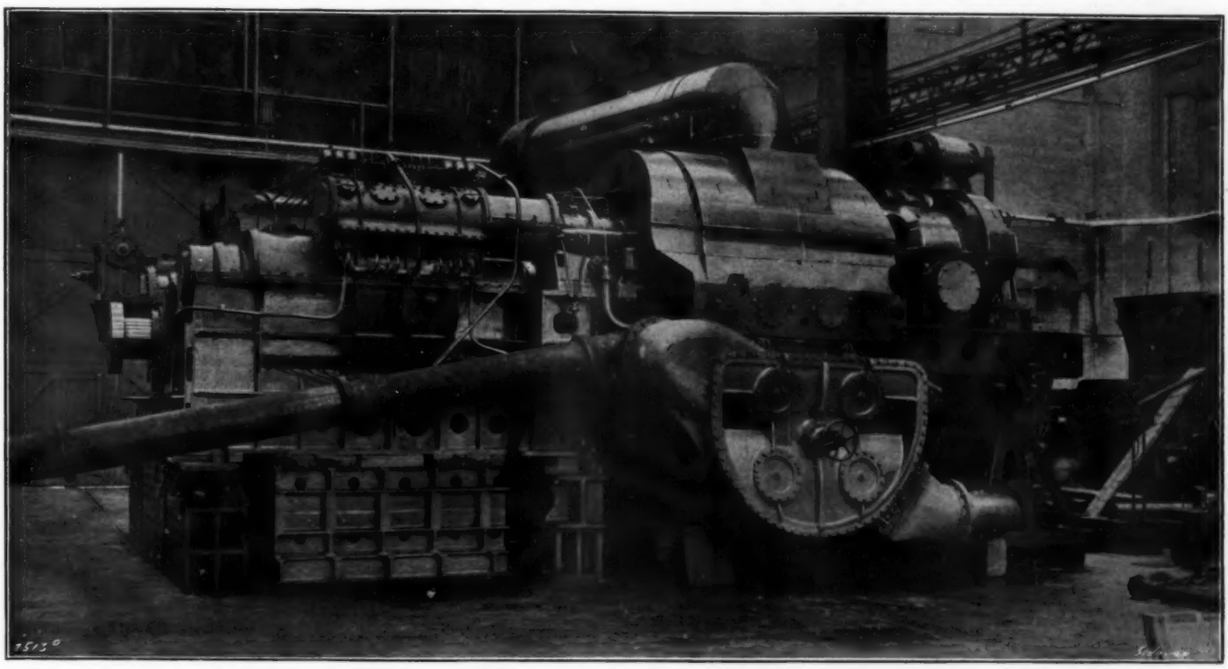

FIG. 47. COMPLETE STARBOARD PROPELLING UNIT FROM OUTBOARD SIDE, AFTER END.

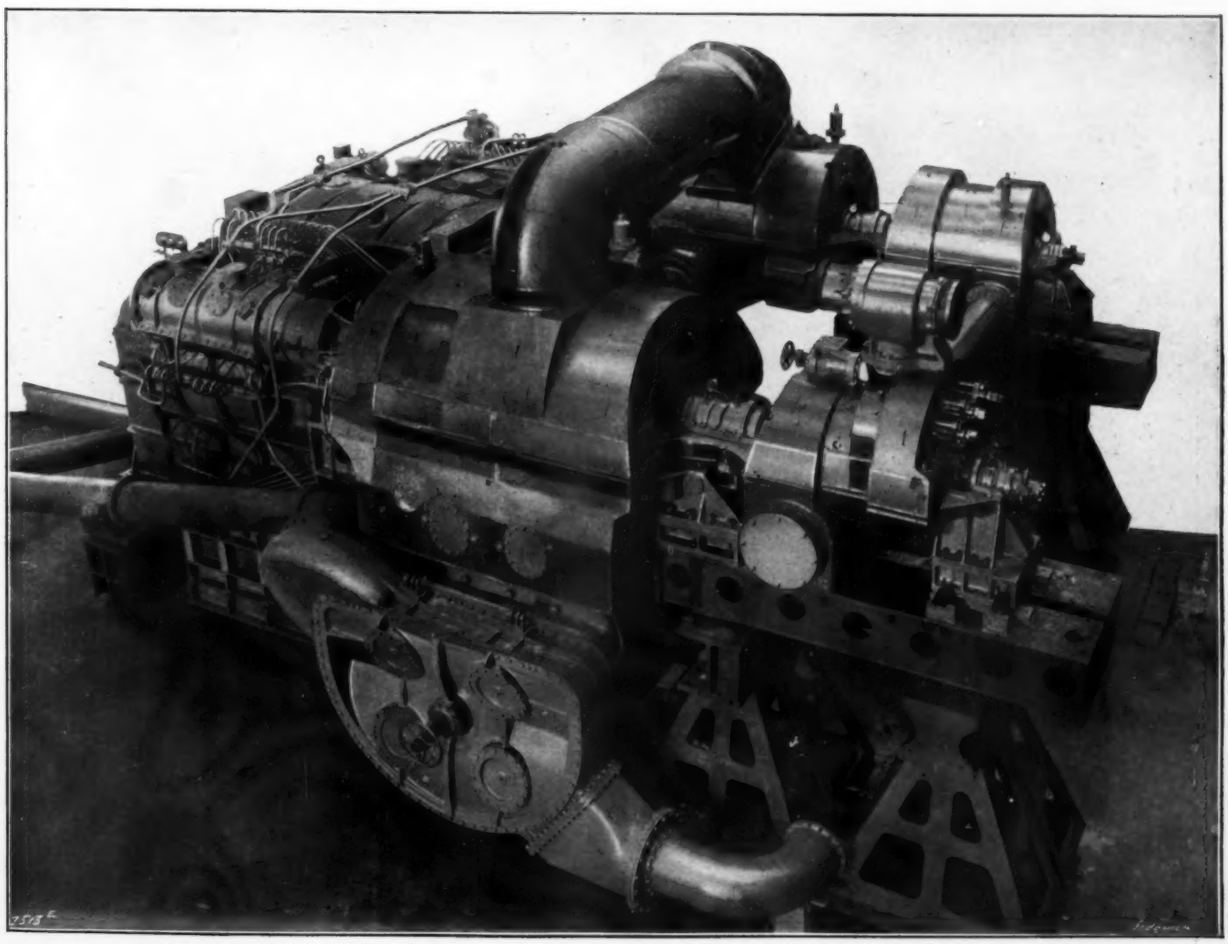

FIG. 48. COMPLETE STARBOARD PROPELLING UNIT FROM OUTBOARD SIDE, FORWARD END.

CANADIAN PACIFIC LINER "EMPRESS OF CANADA"; MAIN TURBINES.

CONSTRUCTED BY THE FAIRFIELD SHIPBUILDING AND ENGINEERING COMPANY, LIMITED, GOVAN, GLASGOW.

(*For Description, see Page* 385.)

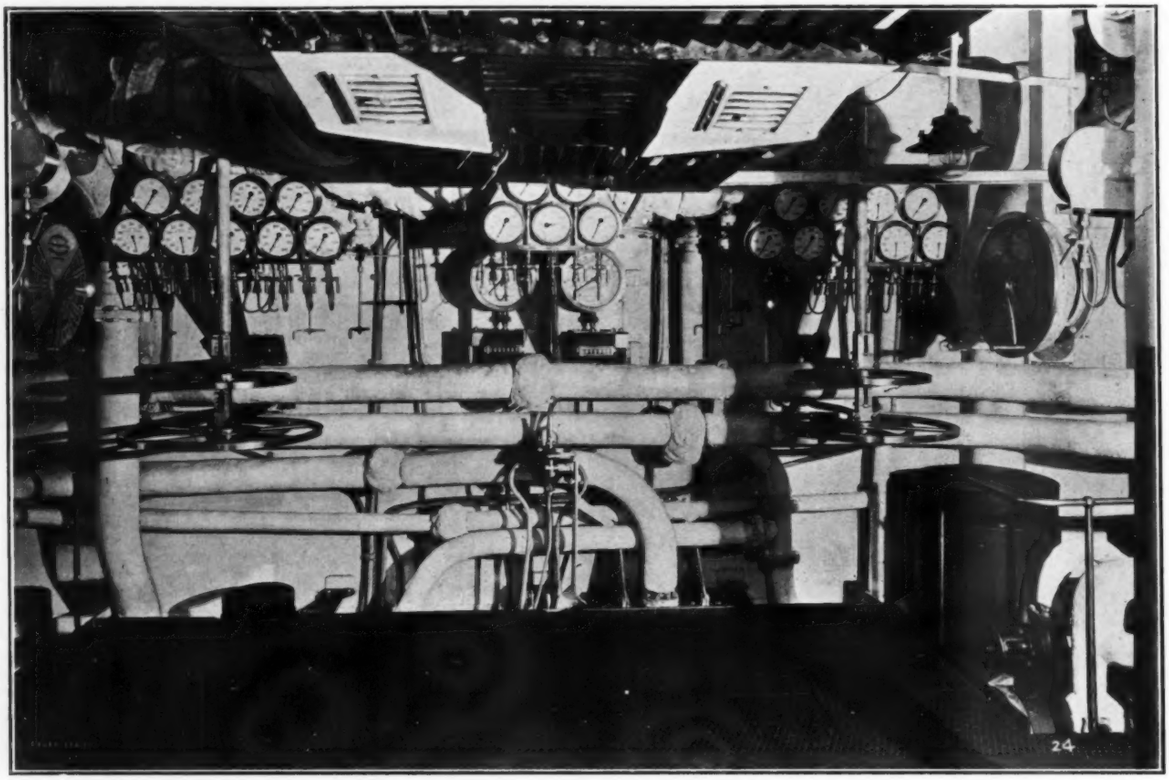

FIG. 49. VIEW ON STARTING PLATFORM, LOOKING FORWARD.

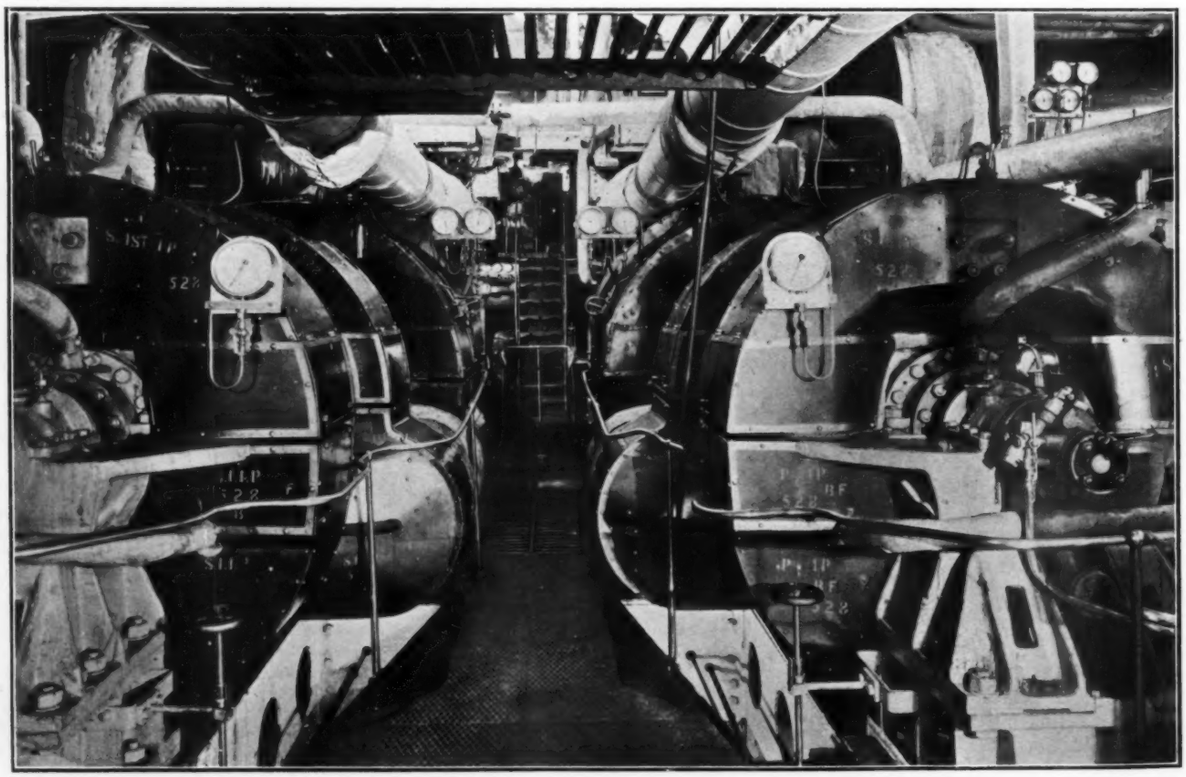

FIG. 50. VIEW OF TURBINES FROM STARTING PLATFORM, LOOKING AFT.

(*To face page* 387.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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ENGINEERING.

FRIDAY, SEPTEMBER 29, 1922.

COAL AND NATIONAL PROSPERITY.

IT is a platitude that Great Britain lives by its exports. Not only for the major part of its food, but also for the major part of the material of its wearing apparel and an important part of its building material it is dependent on other countries. To pay for this material we have either to export goods or render services. To this state of affairs is added the condition that we have a population familiar with and expecting a standard of living, if not the best in the world, certainly well above the general average. Up to the year 1914 we met this state of affairs fairly satisfactorily by exporting coal and manufactured goods and rendering shipping services, and it would appear likely that if we are to maintain our population we must depend on these activities in the future as in the past. There are other methods by which this country can render services which are ultimately paid for in goods, but in the main we must rely on exports and shipping.

Of these two types of activity exports are of the greater importance, and among exports coal occupies the first position. Coal is the only raw material which we have available for export in any considerable quantity, and in addition to the position it occupies in respect to direct sales to other countries, it enters as an important factor into practically every form of manufacture. It is hardly conceivable that this country could live without the export of coal, and while it might be argued that assuming a sufficiently skilful and hard-working population a country which could not feed itself might live by the export of manufactured goods only, the proposition is too abstract to be of any immediate application to our conditions. In 1913 we exported 73 million tons of coal, and while in 1921 that figure had fallen to 24½ million tons, no one could contemplate the disappearance of that remainder with any equanimity.

This country is hardly likely ever to lose sight of the fact that international trade, by which we exist, consists essentially in the interchange of goods and services and that debts can only effectively be paid by such goods or services. The new tariff and the shipping policy of the United States of America would appear to suggest that she has overlooked these matters for the moment, while the excitement with which the proposal that part of the German indemnity should be paid in goods was received in certain circles in this country showed that even here some of us are capable of forgetting these things. In general, however, the inhabitants of this country are fairly clear in their minds that it is on the interchange of goods that our prosperity depends, even though the majority may not realise that on this matter our existence also depends.

In view of the economic position of this country in the world, it is fair to say that the colliery trade is our most important industry. In point of numbers employed it comes second only to agriculture, and since we import some two-thirds of the wheat we consume, all the sugar, tea and cotton and the greater part of the wool and timber, it will be clear that from the point of view of merely existing we owe more to the coal trade than to agriculture. To say this is to make the assumption that our exports of all kinds depend essentially on coal, but the assumption is a fair one. If our coal measures became exhausted, or if we became incapable of working them economically, we could maintain neither our standard of living nor our population, since the whole of our manufacturing ability is bound up with supplies of coal at practicable prices. In view of this condition the serious fall in output of our collieries and the serious rise in cost of their product are matters of very serious moment to a wider circle than that of colliery owners.

The fall in output and rise in cost and the concomitant labour troubles which have distinguished the colliery industry during recent years have not been peculiar to it, but in view of the special position of the trade an important step towards the rehabilitation of industry generally would have been made could the coal trade be brought to a condition of prosperity approaching that which it enjoyed in 1913. From a memorandum just issued by the Mining Association of Great Britain, it appears that in the 15 months ending June 30 last the industry was worked at a net loss of 1,328,962*l.* In 1913 the profits of the industry amounted to 28,000,000*l.* Since the end of June a somewhat better prosperity has come to the industry owing to labour troubles in America, but any improvement based on matters of this kind is of necessity of a temporary nature, and no ultimate prosperity can be built on the troubles of anyone else.

The position which is now before the coal industry and the country is a grave and difficult one, and as the first condition towards remedying any ill is to find out what the ill is, much interest and value lies in the analysis of the position which was given by Sir Richard Redmayne in an address he delivered at "Toc H. Mark II" on the 21st inst. The address, which was entitled "The Truth about Coal Mining," necessarily demands attention in view of the authoritative position occupied by its author. Sir Richard did not confine himself to a mere examination of the causes of the present unsatisfactory position, but put forward various suggestions towards remedy. The present position of the colliery industry was considered by him under three heads, the first concerning the question of ownership of the mineral rights, the second the fall in output, and the third the question of the system of ownership of the collieries.

No question concerning the ownership of the rights in coal, or what is generally called royalties, could in itself, we believe, explain to any important extent the present unsatisfactory position of the industry, and no Government purchase or abolition of royalties is going to furnish any short cut to prosperity. None the less, if there is anything in the present system of royalties which hampers the industry in any way, by all means let it be investigated and rectified if possible. Nothing which may tend in the direction of prosperity should be neglected. Sir Richard stated that the royalty charge varies from 3*d.* to 10*d.* a ton and, including wayleaves, may be taken at an average of 6*d.* a ton. The ownership of the royalties is vested in some 4,000 persons, many of whom have purchased them

in the ordinary way of business so that, excluding confiscation, which we need not consider, if they were expropriated by the State the present holders would have to be compensated. If this were done and the royalties were remitted the condition would simply amount to a disguised subsidy to the coal industry from the State, and if the changes were collected by the State the economic position would simply be what it is now, except that the State would have increased its indebtedness and not improved its credit.

There are apparently certain detail matters in connection with royalties, the rectification of which is likely to assist the industry, and it is satisfactory to note that Sir Richard's information is that negotiations are proceeding which will probably have this end. These matters refer to such things as the fixing of barriers between different ownerships, obstructive tactics preventing the exploitation of certain areas, and so on. There is, moreover, a further aspect of the royalty question which Sir Richard mentioned, but did not enlarge on. This has reference to collieries difficult to work or mining inferior coal. In so far as royalties are graduated to the class of mine they may act as a differential advantage up to 7*d.* a ton in favour of such inferior mines. This may assist in keeping mines open which would otherwise be closed, and in that way will favour the total production of coal. This in turn will assist in keeping the price down. Whether, however, it is to the country's ultimate economic benefit that poor mines should be kept open by a species of subsidy is another matter. The essential need is that the coal industry should pay its way and make a decent profit, and the road to this state of affairs does not lie through artificial aids of any kind. The question of the conservation of our coal supply has a bearing here, but that subject is outside our present scope.

The second of the three heads under which Sir Richard Redmayne considered the present position of the coal industry was "The Fall in Output and Export." This is the essential feature of the whole question. A fall in output following the termination of the Great War has not been confined to the coal trade, but in most occupations the last twelve months or so have seen an improvement. In no other trade, however, has, we think, such a handicap been imposed as that which is furnished by the seven hours' day. Some improvement may be obtained by the further installation of coal-cutting machines, which have increased from 643 in the year 1903 to 3,459 in 1916, and mechanical haulage for the conveyance of workmen to and from their work underground, but it is very doubtful if mechanical improvements of this kind would be capable of making up the whole of the ground we have lost. Assuming the capital to be available, however, it is probable that mechanical improvements in addition to an extensive application of the multiple-shift system would restore our mines to their earlier prosperity.

We note that Sir Richard Redmayne does not think that "very much will be made" of the multiple-shift system. This is a grave opinion. If little is to be done by juggling with royalties, and if mechanical appliances in themselves cannot rehabilitate our coal industry, it means that we must face either a permanently seriously enhanced price of coal, which will largely rule our product out of the markets of the world, or a poverty-stricken industry with a poor standard of performance and a poor state of wages. Sir Richard states that there is strenuous opposition in certain quarters, and markedly in South Wales, to the multi-shift system. This we do not doubt, but matters of this kind are not settled by the opinions of anyone in South Wales or anywhere else. Economic causes bring them about with reference to no one's opinion. The great fall in wages in various trades which have come about in the last few years have not followed anyone's opinion. The abandonment of the great State housing scheme was determined by no individual and no committee. It simply stopped because it was economically impossible. The same thing will, no doubt, eventually happen in the coal industry. The industry will either adjust itself to the conditions it has to meet or it will simply stop. As the existence of some fifty million people depends on it we hardly think it will stop.

There is no benefit in formless optimism on this or any other subject, but we are not able to conceive that the owners and workpeople who live by our coal industry will not prove capable of adjusting themselves to the conditions they have to live with. These things are not done in a moment. Complicated economic movements may take some time to act on all the elements they control, but as it is very certain that no industry can permanently be carried on if it is to lose a million pounds a year, it is also certain that some form of readjustment will be forced by events in the coal trade. The most hopeful line of modification would appear to be in the direction of a more intensive operation of the mines and a multiple-shift would form a very important link in such an improved operation. An almost necessary adjunct would be improved machinery installations in mines, and particularly mechanical developments which a demand would call into being. It must not be forgotten, moreover, that the more capital is sunk in a plant the more reason is there for working it as continuously as possible, so that such mechanical improvements would in themselves tend towards the forcing on of multiple-shift working. There is a further aspect of this matter which should not be neglected. Under the existing wage agreement the miners are in a sense co-partners in the colliery company for which they are working, and although it is probable that the average individual miner has not yet realised this, he will in time. In due course this condition will affect the miners' outlook and make him more favourable to movements leading to higher profits.

An industry which cannot pay its way naturally has difficulty in attracting fresh capital, and it is a simpler matter to talk about improved mechanical appliances in the pits than for colliery companies to pay for them. The industry may be assisted in this direction by the combination of collieries into large groups, which Sir Richard Redmayne puts forward under his third heading as one of the methods by which the outlook of the industry may be improved. There is little doubt but that this movement, which is already in operation, will increase. It is common in industry generally, and gives increased facilities both in buying supplies and selling the product. If the combine is efficiently operated it should also result in decreased cost of production. Various arguments may be advanced against combinations of this kind, particularly from the point of view of increase in administrative expenses, but the continual increase in their numbers in industry generally suggests that on the whole they have advantages over the smaller independent firms. Such combinations may then help the coal trade towards a new prosperity particularly by making more capital available for some of the more promising pits. If to these can be added a better realisation by the men of their stake in the industry and a willingness readily to fall in with such methods of working as will bring the earliest prosperity, a rehabilitated coal industry need not be greatly delayed. If, on the other hand, the men refuse to assist along this natural road to health, they may delay recovery seriously, but the economic laws which mould these things will in the long run have the last word, and the industry will sooner or later fall in with the conditions it has to face.

THE ECONOMIC SITUATION OF AUSTRIA.

THE frontiers of the Austrian Republic are now fixed, and the total area is 33,250 square miles or slightly more than Scotland, and the population is about 6,500,000. This country owes its importance not so much to the possession of natural resources, in which respect it is the least important of the Succession States, but to its central position and the fact that it contains Vienna, the chief centre of civilisation in south-eastern Europe. In spite of the break up of the Monarchy, Vienna must still remain the commercial centre for this part of the continent, for there is no other city to take its place. During the last twelve months great progress has been made in the direction of recovery of an economic life in Austria. Public finance and the state of currency are certainly going from bad to worse but there is a great contrast between this and the condition of most of the population. The report on "The Economic and Commercial Situation of Austria to July, 1922," by O. S. Phillpotts, Commercial Secretary to H.M. Legation, Vienna, which was recently published by the Department of Overseas Trade, provides much interesting information regarding the internal state, export trade, and industrial conditions in this part of the European continent.

During the year 1921 there was a considerable improvement in the provision of food, and consequently in the health of the population. The death rate has fallen during the year to such a level that for the first year since the war the births exceed the deaths. Production has been increased, and although there is still much to be done before the production equals the consumption, the Austrian people are becoming more and more dependent on their own resources. During the two years immediately following the inauguration of the Austrian Republic large credits had to be received from the Allied Governments in the form of imported foodstuffs to feed the population during the time of worst distress. Necessary as such action was to prevent starvation and anarchy it certainly did delay the adaptation of the people to the conditions required to restore Austria. Late in 1920 the allied food credits were exhausted and further grants were refused. Something was done after this by philanthropic agencies to feed the children, but in the main Austria was left to her own resources until the spring of 1922. During this period of eighteen months the Austrian Government had to feed its own population which was still unable to earn its living. This was done by continued inflation of the paper currency. The prices of all commodities consequently increased to such an extent as to provoke riots in Vienna in December, 1921. Assistance could no longer be denied and Great Britain in February, 1922, offered a loan of 2,000,000*l.* as an advance on the larger credits which would become available under the Reparation Committee's scheme of releasing certain Austrian assets from the general lien for specific purposes. France and Italy acted similarly, the one loaning 55,000,000 francs and the other 75,000,000 lira. British American and other bankers are negotiating on the lines of the League of Nations scheme for the restoration of Austria and the provision of a loan to balance the budget in order to save the government from the necessity of further increasing the bank note currency.

No object can be served by giving details of the Budget when the value of the currency has fallen so low as is the case with Austria, for they have little significance by the time they are printed. Food subsidies (in the form of reduced prices for food rations to non-agricultural workers, the cost being made up out of the exchequer) were abolished when Dr. Guertler was Finance Minister last year.

Austria is burdened with an excessive number of State employees, a legacy of the old Empire, and it is estimated that one-sixth of the population are maintained out of government, provincial or municipal funds. While a considerable drain on itself there is also a restriction on trade and commerce through the regulations issued by this mighty army of bureaucrats. All the State undertakings are greatly overstaffed. There are about twice as many workmen employed on the State railways to the mile of track than was the case in Austria-Hungary before the war. This overstaffing is due to the absurdly literal application of the 8-hour day which has more than doubled the men employed on branch lines carrying but a few trains. The proportion of the number of officials to the train-miles run is three and a-half times as high in Austria as in this country.

The loss on the Government works which were formerly engaged on munitions but now are used for other purposes has been so great that the government has decided to accept an offer of the Allgereine Elektrizitaets Gesellschaft of Berlin to take over the largest of them, the Woellersdorf works, on a fifty years' lease.

Agriculture is Austria's most important single branch of production. There has been a progressive improvement in total production during each of the three years 1919, 1920 and 1921, but more than 25 per cent. of the land which was arable in 1912 is still derelict or has reverted to pasture.

The total amount of main crops was still, in 1921, less than half of that produced in 1913. The mistake the Government made was to fix maximum prices below the cost of production. Capital and labour would have been more diverted from the town where it was idle, to the country where it was required, had the town population not been fed during nearly the whole of the first two years after the war by means of food credits.

The production of iron ore, pig iron, ingots and rolled goods has been increased in 1921 50 per cent. over that of 1920, and the progress has been continued in the early part of 1922. The shortage of foundry coke which used to come from Czecho-Slovakia has been made up by German supplies since Hugo Stinnes bought a large interest in the Alpine Montan Company from the Italian shareholders; Czech coke is now available as well as supplies imported from Britain. The development is only arrested by the fact that the Czechs and Italians who mined the ore are now unwilling to work in a country where the exchange is so low. The native Austrian does not like mining or any form of navvy work.

Labour difficulties and the high price of food are the main difficulties restraining the development of the magnesite and salt mining. The coal production has increased to the pre-war value. Before the war practically the only British coal imported was a variety of anthracite. Recently attempts have been made to import British coal in quantity, but these have failed owing to the high freight and transport difficulties, British foundry coke is, however, finding a use in the iron works. In pre-war days about five-sixths of the coal used in Austria was imported. The exploitation of the great unused water power in the Alpine districts and of the Danube naturally attracts attention under conditions such as these. The depreciation of the currency has made it doubtful whether enough funds can be raised to complete the more ambitious schemes and the water power scheme on the Danube has already been postponed. Despite the slump in exports the Austrian industries are producing about 60 per cent. of their capacity, an improvement of 10 per cent. over 1921. The efficiency of labour has been reduced considerably, and the hours of working have been changed to 48 from 52 to 56. Agricultural implement factories are doing well. Motor car production is almost entirely for export, but in spite of the exchange troubles about 4,000 cars were produced in 1921. The textile industry is increasing, and yarns are being exported to Germany instead of to the old normal market of Czecho-Slovakia. The export of wood is proceeding satisfactorily, chiefly to Italy, but the export duty, the prices fixed by the Government and the rate of exchange have all hindered the growth of business in this field. The paper-factories are fully employed and the major part of the production is exported. A type of export duty is levied to ensure a supply of paper for the Austrian newspapers at less than cost price.

The industrial outlook is very depressing. The employers complain of slackness, high costs, the reduction of output through the introduction of the 8-hour day, lack of discipline, an increase of terrorism and the Government regulations limiting the powers of the employers to reduce the number of hands in their works. The labour leaders complain of the poor equipment of the works, but a considerable factor in the diminution of efficiency in the replacement of the Slav workmen, who left at the break-up of the Monarchy by inferior labour. The wages of factory hands and other workmen are regulated from month to month on a sliding scale in accordance with a government index figure. It is argued that the scheme is unsocial, as it means that the wage-earning classes have little or no interest in keeping down the cost of living. There are great troubles ahead when the crown is stabilised or rises, prices fall and the actual currency rates of wages have to be reduced.

THE EFFICIENCIES OF MERCHANT FLEETS.

THE present time, when somewhere about 10,000,000 tons of the world's shipping are laid up for want of profitable employment, is evidently opportune for the consideration of the subject of the efficiencies of merchant fleets, since it is largely on the question of relative efficiency that the future position of the shipping industry depends. It is now quite clear that the total merchant tonnage available is considerably in excess of the immediate requirements of the world's carrying trade, and although the present situation may be improved by the long-anticipated trade revival, there is little room for doubt that competition for freights will be extremely keen for some time to come. To secure them without incurring financial loss the shipowner must therefore pay even greater attention than has been necessary in the past to the reduction of working expenses in every possible direction. Obviously, it will be impossible for more or less obsolete vessels, many of which were retained in service during the war to supply the abnormal demand for shipping which existed at that time, to compete effectively with modern ships in which advantage has been taken of recent advances in naval architecture and marine engineering. While factors, such as rates of wages paid, the owners' experience and business abilities and other matters which cannot be reduced to figures, largely affect the question of operating costs, it will be evident that, *ceteris paribus*, the more modern vessels will be the more economical. It is thus possible to arrive at some conclusions as to the relative efficiencies of the world's merchant fleets by considering the proportion of new tonnage which each contains.

From some statistical tables recently issued by Lloyd's Register, we find that the total number of merchant steamers and motor vessels owned in all countries of the world is 29,255, making 61,342,952 gross tons in the aggregate, and that of this number, 8,522, totalling just over 25,000,000 tons, are less than five years old; the average proportion of new tonnage is thus nearly 41 per cent. The proportions owned by the principal maritime countries individually, however, vary considerably. For instance, the sea-going tonnage of the United States, consists of 3,765 vessels totalling 13,576,640 tons, and of this tonnage nearly 10,000,000, or 73·5 per cent., has been built in or since 1918. This high percentage certainly includes a considerable proportion of vessels of timber construction, which are, of course, of lower economic value than steel vessels of the same age; but with respect to new tonnage, the United States, owing to the enormous war production in that country, far out-distances all the other maritime countries of the world.

The total number and tonnage of steam and motor vessels owned in the United Kingdom, of course, greatly exceeds that owned in the United States, the British merchant fleet including 8,430 vessels of just over 19,000,000 tons in the aggregate, but the number and tonnage of new vessels owned in this country is considerably lower. Altogether 1,927 vessels, making just over 6,000,000 tons, have been added to the merchant fleet of the United Kingdom during the last five years. The proportion of new vessels is thus 31·5 per cent.—a figure which is substantially lower than the average for the whole world and compares very unfavourably with that given already for the United States, viz., 73·5 per cent.

Practically all the other principal maritime countries of the world own larger proportions of new tonnage than that of the United Kingdom, the only exceptions being the British Dominions, for which the proportion is 27·4 per cent., and Spain and Sweden, the proportions for which are 31·3 per cent. and 30·4 per cent., respectively. In the case of Japan, nearly half the total merchant tonnage (46·1 per cent. to be exact) is less than five years old, the new tonnage amounting to 1,656,430 (808 vessels) and the whole Japanese fleet totalling 3,586,918 tons (2,026 vessels). Germany, although her entire merchant fleet now consists of only 1,533 vessels of 1,785,767 tons in the aggregate, owns the next largest proportion of new vessels, the 484 ships, of 780,665 tons together, added to the fleet of that country during the last five years making 43·7 per cent. of the total. The proportions of new tonnage in the French and Dutch merchant fleets are practically equal, the figures being 38·7 per cent. in the case of France and 38·6 per cent. in the case of Holland. For France the new tonnage amounts to 1,369,023 (574 ships) while the corresponding figures for Holland are 1,009,740 tons and 367 ships. The only other nations that need be mentioned individually are Norway, Italy and Denmark, these countries respectively having added 886,539 tons, 922,214 tons, and 305,241 tons of new shipping to their fleets during the last five years. These figures, we may add, represent 36·7 per cent., 34·1 per cent. and 31·7 per cent. of the total tonnages owned in those countries.

By far the greater part of the merchant shipping of the world is composed of cargo-carrying vessels of from 2,000 gross tons to 8,000 gross tons each. Such vessels, in fact, constitute nearly 70 per cent. of the total tonnage while larger and smaller ships account for roughly 13 per cent. and 17 per cent. respectively. The largest vessels are, of course, mainly employed in passenger carrying, and although their aggregate tonnage forms a comparatively insignificant proportion of the world's total, it may be of interest to consider their ages and distribution independently. The vessels of 10,000 tons and upwards now in existence number 331, and their total gross tonnage amounts to 4,642,609. More than half of this tonnage is owned in the United Kingdom, and over 20 per cent. of it in the United States; other countries of the world, between them, own about 23 per cent. of the total tonnage of this class of vessel. For the whole world, the proportion of large vessels built during the last five years is about the same as that of all classes considered together, viz., 40 per cent., but the disparity between the proportions of new vessels owned in this country and in the United States is much less. About 48 per cent. of the large vessels in the United States merchant fleet are less than five years old, while the corresponding figure for this country is 37 per cent. It would thus appear that we are in a better position to compete with that country in the passenger-carrying trade than in the cargo trade. As previously pointed out, however, the age of the vessels employed, is only one factor, although an important one, to be considered in comparing the efficiencies of merchant fleets. Other factors will certainly tend to render the balance more even, particularly in connection with cargo carrying.

ALUMINIUM WELDING LITIGATION.

THE case before the courts in connection with fluxes for use in the welding of aluminium has now passed through the several stages of the Court of First Instance, the Court of Appeal and the House of Lords, and the final judgment is reported at length in the Reports of Patent Cases, Vol. 39, No. 10. Not a large number of actions proceed as far as the House of Lords, so that it is well worth while inventors following the decisions of those that do, in order that they may be fully acquainted with the views of the highest court on what constitutes an invention. In addition, in a case such as the present a considerable amount of information valuable to engineers was brought forward during the course of the proceedings.

The patents in question in this case were two. The first claimed in the autogenous union of aluminium the use of a flux consisting of a mixture of alkali chlorides. The second claimed for the improvement in the above process comprising the use as a flux of a mixture of alkali chlorides and of fluorides.

The defendants in the action it appeared were not in a position to allege that they did not infringe, but they suggested that the inventions were not new at the date of the patents. On this ground they referred to a number of prior documents, the one that was most vigorously put forward throughout the whole of the trial being probably the treatise of Roscoe and Schorlemmer which disclosed the use of sodium and potassium chlorides in the melting together of aluminium scrap. In addition the defendants alleged that many mixtures which were contained within the scope of the patentees' claim were not useful for the purpose described for which reason they alleged the patent was invalid on that ground also.

The Court of First Instance gave judgment for the plaintiffs upholding the patent. On appeal two judges of the Court of Appeal upheld the

decision, but the third Lord Justice dissented. In the final appeal to the House of Lords all the Law Lords confirmed the first judgment and dismissed the appeal. In brief, it was held that the process mentioned by Roscoe and Schorlemmer was not welding, but melting in a crucible, and that there was subject matter in applying to welding aluminium the flux formerly used for soldering. It was also found that the directions in the plaintiffs' specification were sufficient to enable a workman without experience in welding aluminium to obtain welds, and that there were not any mixtures proved by the defendants to be of no use as fluxes and compounded within the scope of the patents.

Lord Buckmaster, in his judgment, fully went into the history of the welding of aluminium, pointing out that before 1907, the date of the applicants' patents, the process of uniting aluminium bodies by the operation of welding was little known and but slightly, if at all, practised. This was not due to lack of demand for such a process, but because the ordinary methods of welding then adopted were not easily applicable to aluminium. Union by soldering, he pointed out, was well known, the fluxes used being selected with the object of removing oxide of aluminium and so enabling close contact between the aluminium and the metals used in the solder to be obtained, but in this process the bodies to be united were not fused. Alkali chlorides and fluorides had both been made the subject of Letters Patent as a flux for soldering aluminium, but not for the autogenous welding thereof. It was held that with the higher temperature involved in welding the operation of the flux had not previously been ascertained, for which reason the House was not prepared to differ from the conclusions that had been formed by the Judge of First Instance who heard the evidence that in claiming this as a new process the patentees were claiming something that had not hitherto been known. Dealing with the chemical publication which described the use of the flux for melting aluminium, although there the temperature would be higher than in soldering, it was held that the operation referred to was not the same thing as that of welding metal. For these and other reasons as explained the patents were upheld.

THE IRRIGATION OF THE SUDAN.

THE announcement made during the past few days of the large contract awarded to Messrs. S. Pearson and Son (Contracting Department), Limited, in connection with the irrigation of the Sudan, marks a distinct stage in the development of that country which is very welcome. The contract relates to the construction of the Sennar Dam, the purpose of which is to render possible the development of a large tract of country known as the Gezireh, lying between the Blue and White Niles. These two rivers, as is known, effect a junction at Khartoum, but the rise from that point of the Blue Nile is on a much steeper grade than is the case with the White Nile, and the former river is thus the more suitable for the irrigation of the Gezireh. The general fall of the land of the larger area which it may ultimately be possible to take in hand is in fact from the Blue to the White Nile; the tract which is now to be prepared for development is, however, only a portion of the ultimately possible amount, and is a strip lying parallel with the Blue Nile and extending to about 300,000 acres.

In our issue of January 7 last year* we gave an account of the major projects which were under consideration for the further development of Egypt and the Sudan, dealing with the Sennar Dam, the Gebel Aulia Dam on the White Nile, the Nag Hamadi barrage in Egypt, and further works, which are in quite the embryo stage, on the head waters of both Niles. The Gebel Aulia project consists of a dam on the White Nile which will serve to store water for Egypt, to supplement that impounded at Assouan. The scheme involves the storage of 5,000,000,000 c.m. of water, which compares with 2,000,000,000 impounded at Assouan. The construction of this dam would, therefore, add very materially to the available supplies for Egypt.

The Sennar Dam, on the other hand, is intended to act more as an irrigation regulator than as a storage reservoir, and the impounded water would at the most amount to about 636,000,000 c.m. The contract now awarded to Messrs. Pearson is for the completion of work which has already been in hand for some time, as will be evident from the illustrations which we are enabled to give in this issue through the courtesy of Mr. O. L. Prowde, of the Sudan Government, who has been connected for some time with the projects for the development of the Blue Nile. The views given on page 400 and annexed show that a good part of the preliminary work has been accomplished, though these views do not, of course, give a really good idea of the extent of the undertaking.

* See ENGINEERING, vol. cxi, page 19.

FIG. 5. 1921—22 SEASON. CORE WALL TRENCH IN FORE GROUND.

FIG. 6. MAIN SLUICE OPENINGS: MARCH, 1922.

The design of the work involves, commencing from the west bank, a length of 250 m. of earth bank, followed by a length of core wall backed by filling. This length will be about 500 m. in length. This is followed by a section of dam in which the regulator sluices will be arranged for the control of the water to the irrigation canals. Following this is a length of about 300 m. of solid dam. Next comes a length of spillway about 190 m., followed by the main sluice section 750 m. long approximately, further spillway openings being arranged above the main sluices. A second spillway section, 190 m. long, follows, and this is succeeded by a core wall and earth backing, and by an earthen bank of a type similar to that at the west end. The total overall length will be about 3·3 kiloms.

The site proved on the whole to give good indications, when explored by borings, of sound rock. So far the indications have been so well realised that for part of the length already put in it was possible to stop excavation at a shallower depth than originally planned, as rock of such good character was encountered. Our illustration, Fig. 1, taken in April, 1921, shows work on such a section. To make sure that water would be cut off from any possible fissures in the rock thus left untouched, a deep trench was cut on the upstream face and filled with rubble masonry. This trench is clearly seen in Fig. 1, and another view showing the trench itself is given in Fig. 2. Good rock was not met with, however, at these levels throughout the section, and Fig. 3 shows a section where towards the downstream side the rock fell away considerably, so that excavation had to be carried to a considerable depth. So far no untoward features have been met with.

The river channel is divided at the site, except during the flood, by an island, and this fact has been utilised in carrying out the work. The work so far accomplished on the dam itself is the result of two seasons' operations on the shallower channel. The work was protected by two temporary bunds, one upstream of the site and one downstream, connecting the island with the west bank. Work across the main channel has not yet been commenced, and will fall into the contract awarded to Messrs. Pearsons. The illustrations given in Figs. 1 to 4 all show the result of the 1920-21 season's operations. The further illustrations,

Figs. 5, 6 and 7, show the continuation of the work in the 1921-22 season. In Fig. 5, which shows excavation to rock for a length of the dam, the section of the dam completed in the previous season may be distinguished in the distance. In the first season the work put in was an isolated section in the river bed; in the second season the work was continued from this section to the west bank. In the foreground of Fig. 5 the point will be seen at which the dam section changes to the core wall previously mentioned, and the narrow trench excavated for this wall will be noticed. The dam itself is being constructed of rubble masonry set in cement mortar. The view, Fig. 4, gives a good idea of the class of work being put into the structure. Squared stones are only being used for facing buttresses, sluices, &c. The low-level sluices are lined with ashlar; the high-level spillway openings, under very much less head, are to be of rubble with the necessary dressed stone facings. Fig. 6 gives a good idea of the work on the main sluice openings. The ashlar is obtained from Seggadi, within easy access of the site by rail.

Owing to the high price to which cement rose some time ago, and the fact that even at those prices it was practically unobtainable, it was decided to erect a cement factory at Sennar. This has now been in operation for some time, and has we understand, been turning out about 1,000 tons of cement a month. The limestone is obtained from Seggadi, while the clay is obtained locally. A red cement is also being manufactured with homrah, local crushed brick, and this material proves very satisfactory in use. The fuel used is coke and charcoal. The wood is cut and burnt by natives in the district, and a considerable supply of fuel has been accumulated.

FIG. 7. STATE OF WORK WHEN SUSPENDED, APRIL, 1922.

The illustration in Fig. 7 shows the work when operations were suspended on account of the money allotted being exhausted. From this stage the work will be carried on by Messrs. Pearson under the new contract. It may be stated that the work already accomplished has been executed on a cost plus percentage contract, which was about all that could be done when it was put in hand. With prices ruling very high and much higher than when the estimates were made, it is not surprising that the original estimate was found to be too low. This has been the experience of practically all large undertakings during recent years. It is satisfactory to know, however, that from the engineering point of view the estimates originally made have so far proved sound. Up till the present there has been practically throughout the work a saving on the depth of excavation found to be necessary, and had normal prices ruled, this would have been reflected, of course, in a material saving.

The plant accumulated at the site includes two Lobnitz suction dredgers, batteries of Allen pumps, electrically-driven, mounted on pontoons, and batteries of Gwynne pumps driven by semi-Diesel engines, also mounted on pontoons. These batteries of pumps are for dewatering the site enclosed between the bunds. There is also a battery of six crushers driven by a producer gas engine plant using wood refuse and other waste. Other plant includes derricks on the site and on a river wharf, a large accumulation of railway material, and so on. The working colony is well housed, and excellent hospital accommodation is provided. A large canteen has been in service, and an ice and soda water factory have also been in use for some time, from all of which it will be evident that a good deal of the preliminary work so essential to a large undertaking of this kind has already been done. The new contractors are, therefore, to this extent saved much of the early preparatory work which on big jobs involves so much care and forethought, for which there is often little to show. The dam, according to the new contract, is to be completed, we understand, by July, 1925. It is hoped to advance the work on the main channel so far in one season as to bring it up to a level which will render unnecessary the reconstruction of the bunds and the dewatering of this section.

With regard to the area to be irrigated, part of the main canal, which is 57 km. long, and the smaller channels has already been dug. The main canal, however, will require to be further widened. This work has been accomplished by 3½ and 4 cubic yard Bucyrus drag-line bucket excavators of two types, one mounted on bogies and running on rails, and the other mounted on skids and rollers. We understand that an order for further excavators has been placed with Messrs. Ruston and Hornsby, Limited.

In conclusion, it may be stated that the complete scheme for the irrigation of the Sudan plans further work, which includes the possible utilisation of Lake Tsana. This, however, is only a project for the somewhat distant future. The population of the Sudan is, of course, sparse, and it is of little use developing such a country ahead of the population. The 300,000-acre scheme now afoot will meet all probable requirements for some time ahead, but the authorities are wise in having regard to ultimate possibilities. It is satisfactory to learn, therefore, that for further developments, which must depend upon the provision of water for which the present scheme does not arrange, conditions are apparently extremely favourable. The neighbourhood of Lake Tsana has been thoroughly explored in a preliminary way, and a suitable site for control works located, so that if political and other conditions are favourable when the need arises the development of further valuable areas will be feasible.

INTERNATIONAL CONGRESS ON LIQUID FUELS.—An International Congress on Liquid Fuels is to be held in Paris from October 9 to 15. There are to be six sections, covering petrol, shale, lignite and peat, tars and benzoles, alcohols and vegetable oils. The congress has been organised by the Société de Chimie Industrielle.

INTERNATIONAL NAVIGATION CONGRESS.

THE International Association of Navigation Congresses whose headquarters are at Brussels, is organising a Congress of shipbuilders, canal, waterway and dock engineers and maritime experts of various countries, to be held in London in July, 1923. This will be the thirteenth congress of the kind, the first having been held in Brussels in 1885 and the twelfth at Philadelphia in 1912. The only occasion when the Congress has been held in England was in 1890 when Manchester was the meeting place. The London Congress will be divided into two sections, which will deal respectively with Inland and Ocean Navigation, the first section will discuss the utilisation of waterways for the production of power, and the best arrangements for locks, &c. It will also receive communications on the influence of surface and subterranean water on the flow of rivers, and on the unification of statistics concerning inland navigation. The second section will consider the port accommodation necessary for ships of the future and questions concerning the loading and discharging of vessels. The communications to be made to this section will comprise questions relating to concrete, liquid fuel, the utilisation of tides for the production of power for port purposes, and the lighting and signalling of coasts. The Congress uses three official languages, English, French and German for its publications, and its international character is shown by the fact that delegates are expected in London from eighteen foreign countries in addition to five of the nations included within the British empire. From the preliminary pamphlet which has reached us, we gather that delegates from ex-enemy countries will not be present.

The British organising committee of the London Congress is under the presidency of Lord Desborough and Mr. R. B. Dunwoody, O.B.E., of 14, Queen Anne's Gate, S.W. 1, is Hon. Secretary. The committee includes representatives of three Government Departments, as well as of all the leading port authorities, canal, shipping and railway companies, numerous engineering institutions, and the principal chambers of commerce are also represented. With so strong a committee there is little doubt that the Congress will prove a highly successful function.

BORON AS A STEEL ALLOY.—The United States Bureau of Mines states that work it has carried out indicates that the use of boron as an alloy confers marked hardness on steel. If the other physical properties of the boron steels are good enough to be applicable to commercial use, their remarkable plasticity at temperatures below the melting points of ordinary steels might make it possible to utilise this characteristic.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The session, 1922-23, begins at University College on Monday, October 2. The programme of public lectures arranged for the first term includes the following: "Standard Ratings for Radiators, Boilers and Complete Heating Installations," by Mr. A. H. Barker; "Recent Photo-Elasticity Researches in Engineering Problems," illustrated with experiments by and of polarised light, by Professor E. G. Coker, F.R.S.; "Recent Excavations in Malta," by Miss M. A. Murray. These lectures are open to the public without fee or ticket. Two special courses of lectures for engineers have also been arranged: Ten lectures on "The Utilisation of Water Power," by Mr. Theodore Stevens, M.Inst.C.E.; and six lectures on "Modern Improvements in Telephony," by Professor J. A. Fleming, F.R.S. The full list of public lectures and particulars and syllabus of the special courses may be had on application to the Secretary, University College, London, W.C. 1.

DRINKING WATER IN MINES.—The safest method of distributing drinking water for use in mines is to pipe it from its source to convenient points for use underground, says the United States Bureau of Mines. While this is the safest method, the use of containers, such as kegs, barrels, or tanks, is probably the most widely practised method, and is satisfactory for many mines, but it requires constant attention to prevent contamination of the water. All containers should be carefully washed and sterilised at least once a week when the source of the water is known to be pure, and daily if the water is infected or its purity unknown. An easy and efficient way to sterilise these containers is to add one-fourth ounce of chlorinated lime to a 50-gallon container, or a proportionate amount for containers of other capacity; fill the container with water and allow the mixture to stand from 4 hours to 6 hours. All containers should be so constructed that they may be kept tightly closed, and so arranged that the water can be drawn only from a tap or drinking fountain, or both.

THE RELAY AUTOMATIC TELEPHONE SYSTEM.

CONSIDERABLE attention has been directed in recent years to the subject of automatic telephony, with the result that the art is continually advancing and developments are keeping step with the latest requirements. This has been the natural outcome of the general speeding up that has taken place in business and social life during the past decade, and of the universal opinion that little, if any, further improvement can be effected in the speed and accuracy of manual operating in telephone exchanges, and there is probably no telephone apparatus whose performance and durability under varied climatic conditions are better known.

The simplicity of design of the relay employed is well shown in Figs. 1, 2 and 3 subjoined. The features of the design have been determined by such considerations as—permanency of adjustment; the operation of spring contacts in a fixed order (where necessary) independent of spring adjustment; constant pressure ($1\frac{1}{2}$ oz.) between contacts, whether these be of the "make" or "break" type; and removal of "spring banks" as complete units without interference with the setting of the individual springs comprising the "bank." The complete bank is shown independently in Fig. 1. To secure uniformity of performance the travel of the armature and the minimum air gap (that is with the armature attracted) are regulated by the thickness of a non-magnetic "distance piece," shown in Fig. 1, inserted between the armature and the iron core; consequently these distances are not liable to variation. The connecting tabs are also a notable departure from general practice, they depend for their seating upon the relay core, not upon the cheek of the coil, and complete rigidity is maintained under all conditions.

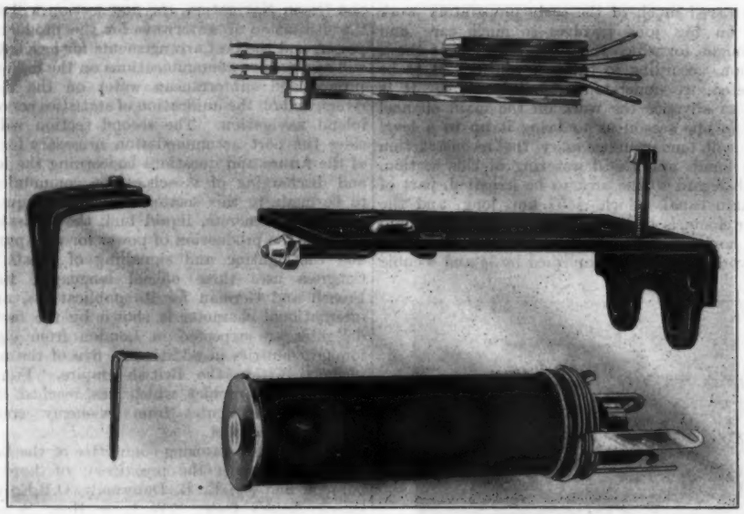


FIG. 1. RELAY DISMOUNTED.

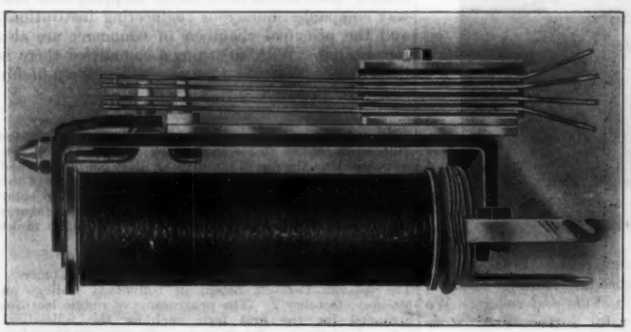


FIG. 2. RELAY ASSEMBLED.

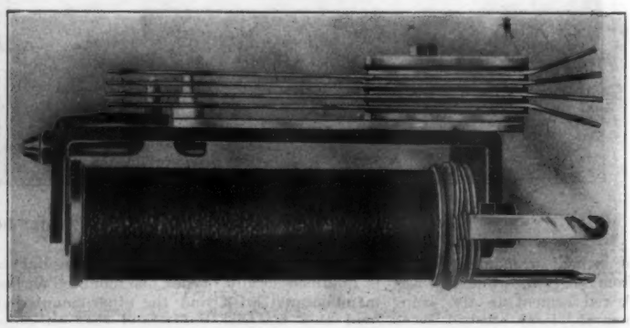


FIG. 3. RELAY OPERATED.

exchanges to meet the ever pressing demand for more rapid and efficient telephonic communication. Inventive effort applied to various basic ideas of automatic switching has resulted in the development of several automatic telephone systems, most of which are founded on the principle of successive group selection through the medium of electro-mechanical switching devices controlled by impulses from subscribers' instruments.

In one system, however, all electro-mechanical switching devices, in the accepted sense of the term, have been excluded, and even successive group selection is only utilised to a limited extent. This system, which has been appropriately called "The Relay System," is built up entirely with relays; all operations in the exchange, inclusive of circuit hunting, connecting, and even ringing, being executed by means of relays, without the intervention of any mechanical gear. In adopting the relay as the fundamental device with which to construct an automatic exchange the designers of the system have evidently been actuated by the resolve to utilise only the simplest apparatus available to attain the object in view. Relays have been used in telephone practice since the inception of manual

Relays possess certain characteristics of peculiar value to an automatic telephone exchange, and the "Relay" system inherits these as a natural right. In the first place they have no appreciable inertia, the moving parts being extremely light and their distance of travel rarely exceeding $\frac{1}{32}$ in. This negligible movement and proportionately small inertia invests the system with a remarkable speed of operation, and contributes very largely towards securing smoothness and quietness in action. For the same reason perfect synchronism is assured between the movements of a subscriber's dial and the counting or recording apparatus in the exchange during dialling operations, as it is hardly possible for an impulse, however rapid, to escape being recorded by apparatus consisting entirely of relays and therefore devoid of slow moving parts. In view of the minute movements and inertia values involved, it follows that wear is a negligible factor, and lubrication of any description entirely unnecessary. The diminutive values of excitation entailed are developed, with correspondingly small current values; consequently, sparking of a destructive nature at contacts is non-existent. The effect of these considerations upon the maintenance and life of the equipment will be evident. The simplicity of relays is important from the point of view of uniform and interchangeable parts, and this has a direct bearing upon the quantity of spare parts to be carried for maintenance purposes.

In this article it is proposed to deal chiefly with the main principles of the system and method of assembly, with particular reference to private automatic exchanges suitable for offices, works, ships, railways, &c. Some information relative to larger exchanges designed for public service is, however, added in conclusion. It is desirable to point out that the system embraces facilities for accommodating private branch exchanges and working over junctions to other exchanges, in addition to caring for numerous special services, but these additional features are outside the scope of this article. Before proceeding to deal with the general working of an exchange of the "Relay" type, it will perhaps be useful to tabulate the essential requirements of any automatic exchange. These are as follows:—

(*a*) When the subscriber lifts the receiver the exchange must connect him to an outward trunking circuit.

(*b*) When a subscriber sends impulses the exchange must connect him to the called party.

(*c*) When the called party is found and is disengaged the exchange must supply current suitable for ringing.

(*d*) When the called party replies the exchange must disconnect the ringing current and supply current for talking.

(*e*) Whilst conversation is in progress the exchange must safeguard the connection against interruption.

(*f*) When the calling subscriber replaces the receiver the exchange must instantly release the connection and restore the apparatus to normal.

(*g*) When a subscriber calls a line which is already engaged, the exchange must give a distinctive "engaged signal" to the caller.

Line Resistance.—In common with all pure automatic systems, as opposed to inter-communication systems, an exchange of the "Relay" type does not entail the erection of more than two wires to any subscriber's instrument. The maximum resistance of a subscriber's line over which the system will operate should be as high as possible. In small "Relay" exchanges, such as are employed for private installations in offices and works, the limiting value of a subscriber's line is not reached until the resistance of the loop (exclusive of instrument) exceeds 250 ohms. This may be interpreted in terms of approximate distances by the list in the next page.

(*a*) 3 circuit miles of 40 lb. bronze wire.
(*b*) 6 circuit miles of 40 lb. copper wire.
(*c*) 14 circuit miles of 100 lb. copper wire.

Over "tie line" or junction circuits, interconnecting two "Relay" exchanges of the aforesaid type, the limiting resistance is very considerably higher, being of a value of 1,600 ohms. Hence, if we assume all the wires in a telephone area to be 40 lb. bronze, subscribers may be located at distances up to 3 miles from the local exchange, and exchanges themselves may be separated by distances of 20 miles approximately. By using 40 lb. copper wire in place of bronze, these distances may be doubled. Abnormally high resistance loops may be worked over successfully by the installation of special long distance equipment. Large "Relay" exchanges designed for public service operate over subscribers' loops as high as 750 ohms. This figure does not represent the actual limiting resistance—a generous margin being allowed.

FIG. 4. SUBSCRIBER'S INSTRUMENT.

FIG. 5. SUBSCRIBER'S INSTRUMENT.

Subscriber's Telephone.—Figs. 4 and 5, above, illustrate two types of automatic telephones used with the "Relay" system. The former is the better known, but the incorporation of the transmitter and receiver in one hand-set on the latter instrument is a convenience appreciated by many telephone users on account of the greater freedom of movement it permits. To the subscriber the calling device is simply a dial, and is much the same in all automatic systems. It has finger holes numbered 1 to 9, followed by 0, arranged counter-clockwise; on being rotated clockwise it returns automatically to its position of rest at a uniform speed controlled by a miniature governor. Impulses are sent to the exchange by the dial disconnecting the line a certain number of times for each digit—this being performed on the automatic return travel and not on the forward movement. Digits, therefore, are received by the exchange in the form of impulses, the dial acting as the converting medium and the speed of impulsing being about 10 to the second.

(To be continued.)

AEROPLANE SURVEYING.

Photography from aircraft received a great impetus by the war. Limited at first to spotting, reconnoitring and filling up the gaps of maps, photographic mapping developed so rapidly, in spite of the great intrinsic difficulties, that, three years ago, more than 800 plates, covering the whole area of Paris, were successfully taken in one day's actual flying, and the city of Washington was well mapped in 2½ hours. The apparatus and instruments required for taking the photographs and for producing correct plans from the distorted images obtained are necessarily expensive, and the saving realised is in time rather than in money. That saving seems sufficiently important, however, even in peace time to justify heavy initial expense on the plan, for instance, adopted by the Inag, the International Aerogeodetic Company, of Danzig-Langfuhr. The company does not place its special apparatus on the market. It undertakes precision surveying of towns and industrial and country districts on a scale of 1 in 1,000; the camera may be lent, so that the client may take the photographs, but the company does the charting. They have, however, placed sets of their instruments, for instruction by their own experts, at the disposal of the Technical High Schools of Berlin and Stuttgart, on the request of the authorities, who acted partly on the recommendation of prominent members of the German survey department.

The chief instruments used are the inventions of Dr. Gasser, of Berlin. Dr. Neuber von Neuburg, who did a good deal of aeroplane photography during the war is one of the directors of the company. When the observer wishes to explore a district or a coast he is approaching, an obliquely-mounted camera is preferable to a vertical camera, which shows roads better, but which gives a wrong idea of heights and buildings. Gasser uses a vertical camera, and the successive images of his series of photographs overlap to a considerable degree, nearly by three-quarters. The camera works automatically, but the intervals and overlap are adjustable. For the scaling the positions of at least three surface points must accurately be known or must be determined—a difficulty, of course, for unknown territory. These points serve as origins for the co-ordinates of the first two images taken. The other plates are similarly examined in pairs, but the surface points of reference can be replaced by conspicuous points common to the two plates; any mistakes made become at once apparent. With the aid of these points and of the known momentary inclination of the camera-axis, which will not be uniform all over the plate, the two plates of a pair can subsequently be brought back, in a projection apparatus, into their original positions relative to one another and to a sheet on which the map is being drawn. By raising the sheet successively to different heights the level curves are obtained, the map growing from the surface upward. The pamphlet of the company, from which we quote, does not enter into much detail, which is necessarily very elaborate. It is mentioned, among other things that, the stereoscopic effect not being utilised, no stereo-comparator is needed, and that the distinction of the two plates of a pair in the projection apparatus is facilitated by illuminating them alternately.

BUSINESS WITH FRANCE.—The representative of the Federation of British Industries in Paris draws attention in a recent letter to the importance of using French whenever possible in approaching firms in that country. French firms are apt to disregard communications in a foreign language, and trade literature or circulars in English therefore frequently fail to achieve any result. He also emphasises the necessity of having catalogues intended for France printed in French, and of using the metric system in quoting prices, weights and measures, &c.

"STRENGTH OF RAILWAY BRIDGES."

TO THE EDITOR OF ENGINEERING.

SIR,—The discussion on the three papers read was so prolonged that it was not possible for Mr. Cookson or myself either to make any remarks upon each other's paper or to reply to the points raised by the speakers taking part in the discussion. I shall be glad, therefore, if you will allow me some of your valuable space in order to say what I should like to have had an opportunity of saying at the meeting.

Having recently carried out a number of tests by means of a hydraulic ram on old girders during which stresses were read by means of an extensometer and deflections by means of direct readings, I am particularly interested in Messrs. Cookson and Nicholas' recent experimental work on girders, not only when forming part of a bridge, but also when tested separately in the laboratory. It is very easy, however, to be misled by results so obtained, and one would hesitate before committing oneself to the opinion that "the expression $\frac{I}{Y}$ or modulus does not accurately represent the capacity of the girder to resist transverse bending." At one stage during the recent experiments to which I have referred the difficulty of obtaining results in accordance with theory appeared to drive one to this conclusion, but the discrepancies were subsequently cleared up, and proved to be due not to any incorrectness of the theory commonly in use, but to small and easily remedied defects in the apparatus employed.

It is important to remember that the strain gauge used by Mr. Cookson, which has a base of 13 in., did not record the stress at the weakest point of the girder, but the average stress over the length of the instrument, the weakest point of the girder being at a section through rivet holes. Further, in the case of the strain gauge on the lower flange which was immediately below the applied load, this instrument recorded the average strain over a section of the girder in which the variation of the bending moment was theoretically in the form of a triangle, but probably in reality in the form of a parabola, and it was impossible to measure the precise stress at the central section by means of an instrument which has a base of 13 in.

It is not clear, moreover, how Mr. Cookson arrived at his calculated stresses, seeing that to these are given in his table the same values both for tension and compression, whereas the diagram referring to the cross-girder gives different moduli for compression and tension respectively. When the assumptions have been adjusted in accordance with the above factors the difference between gauge reading and calculated stress disappears.

Turning now to the tests of the girder as part of the bridge, the "2-8-0" engine on the old cross-girder gives a calculated static stress of 11 tons per square inch, which is compared with the recorded stress of 9 tons on instrument A. Seeing that no allowance in the calculations has been made for any fixity of ends, nor has any adjustment been made to the observed stress on account of the fact that the gauge records an average and not a maximum stress, this test does not appear to show any unexplained "reserve of strength" in the girder.

Taking into account the somewhat rough and ready methods of calculation commonly employed in designing girders the discrepancies between calculated and observed stress do not appear to me to be extraordinary. It is obviously highly important that by means of experimental work such as Mr. Cookson described data should be obtained which will enable calculations of a less rough-and-ready character to be made, especially as regards the strength of existing bridges.

It should not be overlooked that the Ministry of Transport tests were not instituted or carried out with the object of testing the accuracy of the usual assumptions made in design, but merely with the object of finding the increased stress under speed conditions. Anyone who has carefully considered the accuracy of the usual methods of calculation with the object of arriving at the precise factor of safety in existing structures must realise that the calculations made for the purpose of design are more or less of an approximate nature, and include a number of factors of safety which are not usually considered, and that tests by means of strain-meters or deflectometers would invariably shew discrepancies. A large number of these discrepancies can be eliminated by more accurate calculation, and it is due to the existence of these uncalculated factors of safety that engineers are on sound lines in allowing considerable increase of calculated stress in old bridges over the ordinary working stresses used in new design. Personally I have never seen any result obtained from practical testing which would lead one to suppose that the beam theory is inaccurate within ordinary limits of stress.

Mr. Cookson refers to "the origin of the Pencoyd Impact Formula," and it might be well to state more clearly than he has done the reasons why many engineers prefer to deal with live load by means of the "impact" method rather than by means of the "range of stress" method:—

(1) It is generally admitted that a locomotive at high speed inflicts a higher stress on a bridge than the same locomotive stationary.

(2) It is logical when calculating the stresses in a structure to give as the result the actual stresses, as nearly as can be, which occur when the bridge is stressed to the maximum amount.

(3) The range of stress formula in use on the Great Western Railway sets out what the maximum working stress in the girder *should be considering the live load as static*. It does not, therefore, represent what the stress in the girder *is under speed conditions*, and when this system is applied to the calculation of stresses in

existing bridges it does not give a very clear indication of the actual state of affairs.

(4) By the "impact" system, provided the impact percentages can be considered to be reasonably correct, the stresses so calculated represent the stresses which actually occur in the bridge.

If a definite working stress of, say, 8 tons per square inch for steel is adopted it does not much matter to most engineers whether this has been arrived at by taking a factor of safety of 2 on the elastic limit or 4 on the ultimate breaking stress, but seeing that the whole of our present theory of bridge design is based on the assumption that the elastic limit is not exceeded or in other words that the material is elastic and not plastic, it seems reasonable to take the elastic limit of the material as the basis of calculation. By so doing one does not ignore the fact that if parts of the bridge were loaded beyond the elastic limit the structure would not necessarily fail. One merely chooses a working stress at a figure which is designed to ensure that under the most adverse conditions the stress in the material will not approach the limit of its elasticity.

One would have been glad of a little more information from Mr. Cookson of the reasons which have led to the adoption of the figure 4·66 in his formula, especially as regards the factor of safety which it is supposed to provide.

In conclusion I would like to point out that I do not read Sir Benjamin Baker's rule that the stresses in beams are less than when calculated by the beam theory, rather, on the other hand, I think he pointed out that the ultimate strength would be greater. It is surely incorrect to suggest that his theory has anything to do with the discrepancies between calculated and observed stresses within the elastic limit.

Yours truly,
CONRAD GRIBBLE.

York, September 19, 1922.

P.S.—"Since writing the above letter I have seen the letters published in your issue of the 22nd, from Messrs. Tiffany and Thorpe, both of whom confirm the above remarks regarding the alleged discrepancies between calculated and observed stresses. I should like to say that Mr. Thorpe's method for calculating the modulus of a section is that described in Messrs. Johnson, Bryan and Turneaure's latest edition of "Modern Framed Structures," and is undoubtedly more correct than the usual method of calculating the position of the neutral axis from the reduced section through rivet holes. I have found, however, that a more accurate way is to assume a mean section based on the proportion of lengths of drilled and undrilled flange respectively, and this should be used not only when calculating stresses, but when calculating moments of inertia for the purpose of estimating or checking measured deflections."—C. G.

TO THE EDITOR OF ENGINEERING.

SIR,—In the second paragraph of my letter, under the above heading, published in your issue of the 22nd inst., "3½ tons per square inch" should read 8½ tons per square inch.

Yours faithfully,
FRANK TIFFANY.

Bridge House, North Rigton, Huby, Leeds,
September 24, 1922.

"EVAPORATION AND DISTILLATION."

TO THE EDITOR OF ENGINEERING.

SIR,—My remarks on the "heat pump" type of evaporator at the Glasgow Conference of the Chemical Engineering Group were purposely provocative. I am glad they have drawn Mr. Maclean. My remarks included the statement: "there was no doubt that such apparatus gave results equal to those of a quadruple evaporator, but it was necessary to take into consideration all the factors, and on that account I was, as yet, unable to see its superiority." The whole point of the argument arises from the small "temperature drop" that is desirable to take advantage of the best performance of the particular form of "heat pump" used. Unless steps be taken to obtain extraordinary high rates of heat transmission, the plant may become so large and costly as to reduce its economic value below that of a well-designed quadruple effect evaporator. Mr. Maclean's claims are most reasonable compared with those made in the past by other exploiters of this type of plant, but he has not answered this question.

Faithfully yours,
J. W. HINCHLEY.

Imperial College of Science and Technology,
South Kensington, London, S.W. 7.
September 25, 1922.

"STATES AND ENTITIES: WHAT IS ENERGY?"

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to the remarks of "A Constant Reader" in last week's issue of ENGINEERING, it was careless of me not to distinguish between "is" and "means" in my previous note, though I think my point of view was not obscured thereby. I write now to suggest that the term "work" could with advantage be substituted for the term "energy" in the sense that that word is used by "A Constant Reader." What is meant when a body or machine is said to possess x units of potential or kinetic work would then be obvious, and confusion would not arise with the word energy as more widely used in physics. Your correspondent says "it is matter that does the work, when matter is in motion—and at no other time." Matter is always in motion, but is not always doing what is generally understood by "work." I think we must be precise in speaking of motion.

In physics, energy is an entity, that is, it has a real existence and may be discrete and discontinuous.

It seems desirable, if not essential, to distinguish two forms of energy rather than to view electromagnetic phenomena as if they were attributable to attenuated matter as "A Constant Reader" would seem to suggest. The material and radiant forms are physically distinguishable, and I do not think it makes for clarity or even simplicity to regard "light" for example as having the substantial character he associates with matter, though both forms have inertia. Matter reduced to electrons remains matter, and as such never reaches a certain limiting velocity attained or manifested by radiant energy or quanta. I do not share "A Constant Reader's" apprehension as to the inconclusiveness of photographic evidence at the solar eclipse—and possibly the bending of a ray of light in its passage past the Sun's gravitational field will have been confirmed before this appears in print.

Yours faithfully,
"A CONSTANT READER OF ENGINEERING SINCE 1910."

September 25, 1922.

"STANDARD COEFFICIENT FOR PIPE RESISTANCE."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Haigh's letter on the above subject in your issue of September 15 raises a very important issue. I would point out, however, that D'Arcy's coefficient is not the only alternative to Chezy's coefficient. There are altogether four coefficients in general use amongst engineers depending upon whether the diameter or the hydraulic mean depth of the pipe is used and whether or not the gravitational constant is incorporated. It is, however, quite immaterial which is used provided that the same meaning is attached to the same symbol. The question of coefficients, however, is a side issue, the main purpose of my paper was to demonstrate the advantage of treating the frictional coefficient simply as a function of $v\,d/\nu$ when applied to hydraulic problems in general and to deprecate for practical purposes any attempt at giving it mathematical form for which there is no real need any more than there is for a stress-strain curve, or a magnetisation curve. The method affords a means of correlating experimental observations covering a wide range of speeds, different forms, quality and dimensions of surfaces, different fluids, whether gaseous or liquid, and at all temperatures for which the viscosity is known, and for this reason bids fair to end the chaotic condition of the subject of the frictional coefficient in pipes and channels.

Yours very truly,
E. PARRY.

Queen's House, Kingsway, W.C. 2,
September 20, 1922.

"THE COMMERCIAL VALUE OF KNOWLEDGE."

TO THE EDITOR OF ENGINEERING.

SIR,—I think that "Graduate's" letter appearing in your issue of the 1st inst., has to a great extent diverted the correspondence on this subject, from the lines of your original article, which, as I understood it, was intended to be a criticism of the subject as a whole, and not as applied to a few special and unfortunate cases, least of all to the ex-service man, with whom I think every one has the greatest sympathy.

In your article you mentioned that the possession of knowledge can, on the one hand, be considered as bringing its own reward, in the personal intellectual pleasure it affords its possessor, but that on the other hand the student who takes a university or technical college course is not satisfied with this only, his object being eventually to turn the knowledge he hopes to obtain, to a definite financial value.

In my opinion, one of the main reasons for the difficulties encountered by youths endeavouring to obtain their first commercial position after receiving a technical training, is that the professional teaching staffs, particularly in the bigger colleges, regard the whole matter from the point of view first mentioned, namely, that "the possession of knowledge brings its own reward, &c.," and are completely out of touch and out of tune with the commercial life about them. Moreover, I am afraid that many of them greatly resent "debasing commercialism" being mentioned in connection with their "academic discourses," always of course with the exception as to when it affects their own personal position.

I recently had an opportunity of speaking with a member of the teaching staff of one of the universities, and was very astounded to find that he had not the remotest idea as to even the approximate costs of the chief raw materials used in connection with the industry he is supposed to be teaching to the students, although these prices vary considerably with the degree of purity required in the manufacture of different articles for a like purpose. On attempting to pursue the matter further, I was rewarded with a most superior look and smile, insinuating that it was not necessary for men of his intellectual attainments to trouble with questions of such a mercenary nature. Shortly afterwards I met a man who had spent four years at the same university, and his attitude towards commercial matters was exactly the same as that of his professor—an unfortunate but obvious result.

The manufacturer is not a philanthropist, and his object in employing a technically-trained man is purely commercial, and has for its aim, either the improvement of the quality of his output, the reduction of his manufacturing costs, or the development of new products, &c. All of these entail a thorough appreciation of commercial values, and it is here that the man just leaving college fails, not, I think, due to faults on his part, but purely and simply to the fact that he has never had this "debasing" yet very essential side of his future profession placed before him.

Yours faithfully,
C. SAXTON.

Talbot House, Arundel-street, Strand, London, W.C. 2.
September 20, 1922.

TO THE EDITOR OF ENGINEERING.

SIR,—After reading the self-opinionated letters of "Anti-Professor," one feels that like the lady in the play, he "doth protest too much." His assurance that he "knows what he is talking about" leaves a more timid creature aghast. It is with relief that one turns to the thoughtful letter of Mr. H. S. Burn. As a clear statement of the relationship between technical knowledge and practice it leaves little to be desired.

Your correspondent "R. P." insists that graduates are handicapped by asking for a living wage. But whether they ask for such a wage or not they do not seem to meet with much consideration. I am an Hons.B.Sc. (Civil) with four years' experience (incidentally, obtained before graduation). I have a valuable exhibition which enables me to offer my services in exchange for good experience and a nominal salary. Still, after a three months' search I can't find an employer to take me on these terms. In a few weeks my exhibition will be withdrawn if I can't get a job.

Times are very difficult to be sure, but posts are still being filled. After my experience of the last few months I can affirm that there is a fairly widespread feeling against university men. I say "feeling" advisedly—the prejudice partakes more of the nature of a feeling than of a reasoned opinion.

I am, Sir, yours faithfully,
J. JAGGER.

Prospect-place Schools, Cleckheaton.
September 25, 1922.

ECONOMY IN THE USE OF MACHINE TOOLS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your editorial commentary on the annual report of the Department of Scientific and Industrial Research will be read with considerable interest by all who desire to forward the advancement of technical knowledge as applied to industry. Without belittling in any way the valuable work done by this department we should like to suggest that there is an extremely urgent demand for educational work on the economical generation and use of power. It may be argued with justice that the learned societies and the technical press devote a large amount of attention to this subject. Without disputing this, one is inclined to wonder whether the methods of presentation are efficacious, as there is far more evidence of inefficiency than of efficiency in our workshops and power houses.

One of the most prolific sources of power waste and one that is rarely dealt with by any technical body or journal lies in our methods of cutting metal, more especially on machines using tools of the lathe type. What tremendous saving of power there would be if all the lathes in this country could have their power requirements reduced by more efficient tool shapes. For a long time now we have advocated the adoption of the standardised and centralised tool system whereby all tools used in the workshop are made in a central department to standard shapes and sizes. Our work in this direction, however, is handicapped by a lack of data on power consumption due to tool shape. The more one studies this question the more one is convinced that reliable data on the variation in power consumption due to change of tool shape would go a long way toward bringing about a considerable saving of power in our workshops.

The subject is a vast one, too great for any one firm to tackle, but not outside the scope of, say, the National Physical Laboratory or the Institute of Mechanical Engineers. What we should like to see done is to take a few general operations such as heavy turning and facing in steel and cast-iron, fix on a particular depth of cut and rate of feed, then experiment with different shapes and angles of tools, taking records of durability, power consumption, metal removed and condition of tool at intervals. The whole series could be repeated at different rates of feed or depth of cut.

With such data before them those interested in metal cutting would be able to decide on the most efficient tool for any purpose. The tools chosen would, of course, represent a compromise between cutting ability and durability. We should be pleased if allowed to co-operate in any research work of this kind by the loan of a machine for making the tools. We trust the publication of this letter in your valuable journal will result in some effort being directed to the end indicated.

Yours faithfully,
FOR ALFRED HERBERT, LIMITED,
J. PICKIN.

Coventry, September 27, 1922.

CHELSEA POLYTECHNIC.—The Chelsea Polytechnic, Manresa-road, Chelsea, S.W. 3, has issued a leaflet giving particulars of day and evening classes in metallurgy, for the session 1922–23.

KEIGHLEY ASSOCIATION OF ENGINEERS.—Through the courtesy of Messrs. J. Blakeborough and Sons, Limited, Brighouse, a visit has been arranged to their Woodhouse Works on Saturday, October 7.

NOTES ON NEW BOOKS.

THE units forming part of the fleets of all nations are given in the "*Taschenbuch der Kriegaflotten*" for the current year, the twentieth annual issue. It is edited by Captain B. Weyer, formerly of the German Navy, and is published at the price of 10*s.* by J. F. Lehmanns Verlag, Munich. It opens with tables giving the name, year of launch, tonnage, speed, armament, &c., of each warship, or group of warships belonging to the different nations, followed by views, side elevations and deck plans of typical ships. The articles of the Treaty of Versailles bearing upon the German naval power are quoted. Then follow particulars of the naval gun types adopted by the various navies, namely, calibre, length in calibres, weight of guns, of projectiles, muzzle velocity, &c. The losses sustained by the German Navy in ships of all classes, and airships, are stated in further tables. The book also contains naval data of a general character. The fifth section of the book opens with a chapter describing the economic development of Germany, down to the year 1914. The book closes with conversion tables and with an index of the names of all the world's warships.

There is no doubt that the public of most civilised countries of the world is now beginning to realise the importance of aircraft, both from the military and commercial points of view, and for this reason we imagine that the information relating to British and foreign machines and engines given in Jane's "*All the World's Aircraft*" will be of interest to an even larger section of the community than was formerly the case. Since the work has now reached its twelfth year of publication, the character of its contents will be familiar to most of our readers, but we may remark that the current volume differs from its two predecessors in that it has been found possible to omit matter relating to the war period and to confine attention to the year 1921 only. The first part of the work contains historical notes of the year's work of each nation in military, naval and civil aviation, together with much useful information relating to aeronautical officials, departments, associations, &c. Particulars are given in the next section of the various types of machines employed, with numerous reproductions of photographs and outline diagrams in each case; helicopters and gliders are also dealt with in this section. The remaining sections are devoted, respectively, to aircraft engines and airships, and with regard to the latter, it must be admitted that the year under review was one of negative progress as far as this country was concerned. The annual is edited and compiled by Mr. C. G. Grey, editor of "*The Aeroplane*," and it is published by Messrs. Sampson Low, Marston and Co., Limited, 100, Southwark Street, London, S.E. 1, at the price of two guineas net.

One of the greatest benefits our chemists could possibly confer on the boiler user would be to devise an apparatus which would constantly indicate or record the hardness of the feed-water delivered to the boilers. It may be that the chemical reactions are too slow, or the physical conditions too delicate to permit of this being done, but vast ingenuity has been spent on devices of infinitely less practical value. Till the suggested apparatus has been produced the boiler operator has to rely upon periodic tests of the water as a guide to the management of his softening plant, and in "*Boiler Feed Water*," by Percy G. Jackson, F.I.C. (London: Charles Griffin and Co. Limited, 1922; price 5*s.* net) he will find an inexpensive little book which will give him all the information he needs for such tests. The book, which is now in its second edition, is not addressed to the chemist so much as to the engineer, who will find in it nothing unintelligible to anyone with an elementary knowledge of chemistry, and much that is of direct practical value to those in charge of boilers and softening plants. It is a book which should be in the engineer's office in every power plant, for proper water treatment is essential to economical operation except in those few fortunate places where the supply is naturally soft and pure, or where the conservation of steam is so perfect that the make-up water can be supplied by evaporators. The latter condition, indeed, is the ideal at which power-plants ought to aim.

At most of our ports provision is made by which sea-going engineers can work up for their Board of Trade certificates, by attending evening classes, whilst maintaining themselves by working in the shops during the day. Institutions established to this end serve a very useful purpose, and as the standard of theoretical knowledge demanded is not high, the teachers and lecturers do not necessarily require more than a somewhat elementary knowledge of scientific principles. They have, however, generally a pretty adequate knowledge of mechanism and of troubles likely to be encountered at sea. Several of them have written quite valuable treatises along this somewhat modest line, but others, somewhat more ambitious, have ventured out of their depth when they have taken to authorship, and spoilt what might otherwise have been a useful work by embodying in it their own misunderstanding and misconceptions. An example of this such misdirected energy is provided in "*Marine Engines*," just published by Messrs. Simpkin, Marshall and Co., price 21*s.* net. The author is Mr. A. Ritchie Leask, principal of Leask's Engineering Colleges, London and Cardiff, who has ventured to discuss the steam turbine with an obviously very imperfect knowledge of theoretical principles. We have only room for two quotations. On page 63 we find "Theoretically, then, the efficiency of the turbine is 50 per cent. of the kinetic energy of the steam." Further evidence as to the vagueness of the author's ideas of efficiency are afforded by the following quotation from page 137, where he is comparing the relative efficiency of turbines and reciprocators: "Now, as already stated, kinetic energy varies as V^2 in feet per second. The relative velocity of the two, turbine and reciprocating engine, is therefore about $200 \div 7 \cdot 5 = 26 \cdot 4$ to 1, and V^2 = a ratio of 700 to 1 nearly; but instead of that ratio of efficiency being reached the claimed superiority was only 1·2 to 1."

Certain treatises rapidly establish a position as amongst the classics of the engineering profession. No doubt, owing to the steady increase of knowledge, the position of such a work is less impregnable than that of a literary classic, but by frequent revision certain technical works long maintain their popularity. Amongst these must be included Mr. Edward Wegmann's book on "*The Design and Construction of Dams*." First published in 1888, this work rapidly established itself as a necessary part of the equipment of the engineer interested in the impounding of water, and advantage has been taken of frequent new editions to keep the subject matter well up to date. A seventh edition has just been published by Messrs. John Wiley and Sons, Inc., New York, and can be obtained from Messrs. Chapman and Hall, Limited, London, at 50*s.* net. Amongst the new matter is a chapter on "Crest Gates and Siphon Spillways," and a full description is given of the construction of the Kensico Dam, New York, on which an extraordinary rate of progress has been attained. The Camarasa Dam, Spain, which being 335 ft. high from base level to crest, ranks as the highest gravity dam in the world, is also fully illustrated and described. In addition to the very valuable and comprehensive technical matter, the author has also a short but highly interesting description of the dams erected by beavers. The new edition comprises over 550 pages of text and 111 large plates, in addition to numerous other illustrations.

Up till about 1860 the world's supply of cinchona bark, the raw material for the manufacture of quinine and the other cinchona alkaloids, came from the tropical forests of the eastern slopes of the Andes. In 1860 cinchona species were introduced into British possessions; within twenty-five years Ceylon became the principal source of supply, but was supplanted by Java. In 1913 Java produced 23,000,000 lb. of bark, India 2,000,000 lb. and other countries 400,000 lb., and those figures hold again at present, though a good deal has happened meanwhile. The overproduction of bark led, nearly ten years ago, to an agreement between the planters and the quinine manufacturers of Java and the Netherlands and of other countries, and this agreement, which regulates the price of bark by the price of quinine, was renewed in 1918. But the Empire is, in a way, dependent upon the Kina Bureau for its supply of quinine, and the Government of India and the Imperial Institute are anxious to foster the demand for quinine from India which, in 1900, had produced 4,000,000 lb. of bark. The cultivation of the bark has also taken root in British Malaya, in St. Helena and in the former German Colonies of Tanganyika and the Cameroons; but these countries are hardly producing so far. The whole problem is reviewed in one of the reports of the Imperial Institute on "*Cinchona Bark and Myrobalans*" (London: John Murray; price 4*s.* net). The myrobalans with which the volume before us also deals, are the dried fruits of species of terminalia, mainly t. chebula, the deciduous forest trees known as the chebulic or black myrobalan. The fruits are the principal tanning material produced in India and have largely been exported from there, chiefly to the United Kingdom and other parts of the Empire, and next to these to Germany. Before the war some 1,400,000 cwt. of myrobalan were exported, representing a value of 400,000*l.*; the trade fell off during the war, and recent statistics are not given. The contents of tannin in the dry material reach about 47 per cent. and in some samples from Madras possibly 68 per cent. The myrobalan tannin is much cheaper than the sumach product, but it does not give equally bright colours.

The author who endeavours to write what is sometimes known as a non-mathematical and essential practical book upon electrical engineering finds many pitfalls. Mr. W. R. Bowker, in his "*Electric Circuits and Connections*" (London: Crosby, Lockwood and Son; price 15*s.* net), prides himself that his book is of this class, but he also shows a fondness for writing down formulæ without much or always clear explanation. Fortunately he does not attempt anything ambitious in this way, and it is only in the introductory part of the work that such is found. Surely in a non-mathematical book the use of Greek letters is something of the nature of a luxury, but the author is not always content to use but one Greek letter as symbol for each quantity and his poor non-mathematical reader is expected to know that λ and θ in the different equations are the same. We are puzzled by his reference to "angle cos λ." The main part of the book treats of electrical circuits and must be of considerable value to wiremen and young electrical workers. The connections of motors, dynamos, starters, lighting and power schemes, switch boards, rotary converters and many other electrical circuits are shown by means of diagrams and are described.

Even elementary text books are written nowadays with a bias towards specialisation. Mr. J. Paley Yorke, M.Sc., the head of the Physics and Electrical Engineering Department of the London County Council School of Engineering and Navigation, Poplar, has written a first year's text book on "*Magnetism and Electricity*" for students who intend later to study electrical engineering. The book is published by Edward Arnold and Co., at 5*s.* net, and is an admirable work of its kind, it is well written and fills the requirements of classes in junior technical schools in every way. The author says in the last lines of his preface that as an official under the London County Council he is required to state that the council is in no degree responsible for any of the opinions that stand under his name. We hope the London County Council have not framed such a regulation, at any rate as regards text books. One recognises the modesty of the council in their desire not to be associated in any way with the statement of such a fundamental truth, as Ohm's law, or their knowledge that they cannot by vote alter the direction of a single line of force! But really, Mr. Yorke, if they knew that you were writing "Nobody knows what electricity is" (page 54), do you think they as a council, would admit such ignorance?

It is a pleasure to come across a book on elementary science in which there is some endeavour shown to direct the attention of students to the limited degree of precision of the crude instrument used in any determination. A knowledge of the limits of accuracy of any device are essential, and when once this knowledge is acquired there will be no tendency to run riot with decimals in a calculation based upon the readings. One never forgets seeing such things as calorific values determined from readings made with not-very-accurate instruments calculated out to many significant figures. Mr. W. J. R. Calvert, M.A., an assistant master at Harrow, has written a text book on "*Heat*," in which wherever possible the degree of precision of any measurement is stated. Another point of value in this work is that the author has not spoken of the effects of heat without giving a good idea of their magnitude. The development of a sense of the proportion of various heat actions is a very commendable thing. This book is published by Edward Arnold and Co., at a price of 6*s.* net, and is written as a text book suitable for general school education purposes, but in addition has many supplementary chapters and detailed footnote explanations which make it a suitable book of study for those proceeding to an examination of the standard of the intermediate B.Sc. This is a very good work which one can recommend to all who are undertaking work of this standard. There are references to original papers which increase the value of the book to a really earnest student.

FIRE AND SALVAGE BOAT FOR CALCUTTA.—A steam fire and salvage boat supplied by Messrs. Merryweather and Sons, of Greenwich-road, London, to the Calcutta Port Commissioners, has recently satisfactorily completed her trials at Calcutta. The boat, which is named Alpha, is constructed of steel and has an overall length of 107 ft. 6 in., with a beam of 18 ft. and a draught of 5 ft. She is propelled by compound engines driving twin screws and developing 525 i.h.p., and giving a speed of 11 knots. Steam is supplied by two horizontal water-tube boilers of the quick steam-raising type, and the two fire and salvage pumps are of Merryweather's double-cylinder vertical "Greenwich" type with a combined pumping capacity of 4,000 gallons per minute. This would be equivalent to the output of about 10 of the ordinary type of land fire engines.

MACHINE FOR MEASURING GEAR TEETH.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED, ENGINEERS, MANCHESTER.

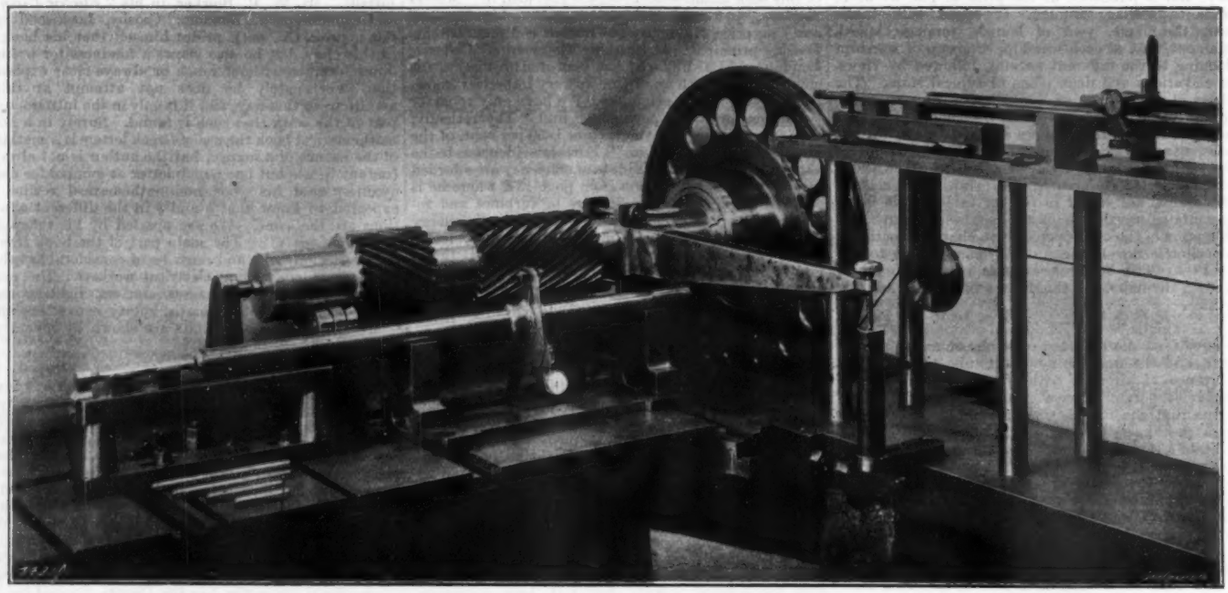


FIG. 1.

IN his contribution to the discussion on reduction gears, at the April meeting of the Institution of Naval Architects, Mr. H. Guy, of the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, exhibited a diagram showing the errors found in a pinion purchased and tested by his firm. The machine used in measuring the errors was designed and made at the Trafford Park works of the Metropolitan-Vickers Company, and is represented in Fig. 1 on this page, whilst Figs. 2 to 9, page 411, show clearly the details of its construction. Since the errors were to be determined in units of $\frac{1}{10,000}$ in., it was essential that the apparatus should be designed so that both the pinion under examination and the gear used in estimating its errors should be free from all unavoidable constraints, and as it will be seen from what follows, this end has been very successfully secured.

The teeth of a helical pinion may be said to have two pitches, viz., an axial pitch and a circumferential pitch, and both are measured with the machine under review. The pinion to be tested rests on rollers, and alongside, and parallel to it is arranged a truly straight and cylindrical shaft or arbour resting freely in vees. This carries, a little distance from its mid-length, a micrometer indicator consisting of a multiplying lever, of which the short arm carries a spherical head, which is brought into contact with the surface of the tooth to be measured, whilst the longer arm actuates a dial micrometer, which is clearly visible to the front in Fig. 1. The arbour rests, as stated, in vee guides, and can thus freely slide along a line parallel to the axis of the pinion. It is "located" axially by bringing its end into contact with a length gauge which can be seen to the left in Fig. 1. A number of these gauges are provided and are shown in the foreground. They differ in length by an amount equal to the axial pitch of the teeth, and by replacing one by the next in series the arbour and its indicator can be slid accurately through a distance equal to the axial pitch. Provided that the arbour is prevented from rotating during the transfer, the indicator should, if the teeth be accurate, show the same reading at both positions. To prevent rotation, a finger shown below and behind the saddle carrying the indicator, rests lightly against a bar which is adjusted to be parallel to the pinion axis.

In using the apparatus, the shortest gauge is first inserted in position and the arbour and indicator "located" accordingly. The pinion is then rotated by the arm and fine adjusting screw shown on the right, until a tooth comes into contact with the ball end of the multiplying lever, and the adjustment is continued until the needle of the dial micrometer reads zero. The end gauge is then replaced by the next in series and were the axial pitch exact, the needle should again read zero, the actual reading indicates the error in axial pitch. A longer gauge is now inserted and a fresh reading taken with the arbour in its new position. After a series of such measurements is completed the pinion is rotated through an angle corresponding to the circumferential pitch and a fresh set of readings taken, this operation being repeated until sets of measurements extending round the whole circumference have been obtained. A comparison of the differences of the sets of dial readings thus obtained gives the errors in circumferential pitch.

In order to secure precision in rotating the pinion through the desired angle a wheel is mounted on right-hand end of the pinion, and in order to obtain the requisite concentricity, a split cone is employed to clamp together this wheel on the pinion. In a flat groove turned in the rim of this wheel there rests a flexible steel tape, which leads horizontally off the top of the wheel, and after passing over pulleys is kept under constant tension by a weight attached to it. The pull of this weight is balanced by another attached to a cord, which, as is clearly shown in Fig. 1, passes round the wheel in the opposite way to the steel tape. The horizontal portion of this tape passes over and along a bar on which slides a shoe which can be clamped to the tape at will. On a prepared surface on this shoe rests the ball end of a multiplying lever attached to a second dial micrometer which can be seen to the right of Fig. 1. This dial micrometer is fixed to a second arbour, running in guides, and adjusted in position by a micrometer head and a set of gauges, which differ in length by an amount equal to the circumferential pitch. Before a rotation of the pinion is commenced the shoe is clamped to the steel tape, and the position of the arbour adjusted until the dial micrometer reads zero. The gauge interposed between the arbour end and the micrometer head is then replaced by the next in series, which is shorter by an amount equivalent to the circumferential pitch. The wheel is then turned through approximately the correct angle, and this is then adjusted by means of the screw and lever already mentioned, until the needle of the dial micrometer stands again at the zero mark, which thus indicates that the pinion has been rotated through exactly one pitch.

Referring now to the details of the machine a plan view is represented by Fig. 2 and an end view in Fig. 3, where the rollers on which the pinion is supported are clearly visible. The arbour which slides parallel to the pinion axis is denoted by A and is shown in contact with one of the axial gauges at B. The section on A B, Fig. 6, shows at C the arm which, abutting against the face of the block D, registered the angular position of this arbour. In the same figure E denotes the lever used in making fine adjustments of the angular position of the pinion, which is effected by the fine threaded screw provided with milled head as shown at F. The wheel, on which the steel tape is wound, is shown separately in Fig. 7, whilst the weight which keeps the tape under constant tension is represented at G, Fig. 3, the corresponding weight on the cord to balance this being shown at the end of the cord, where it is denoted by H. The arbour which carries the second dial micrometer by use of which precise angular movements are obtained, is shown at I, Fig. 2, and also in section in Fig. 5, where the shoe to which the tape is clamped as required is denoted by J. The details are shown more clearly in the enlarged views, Figs. 8 and 9. In Fig. 8, the K represents the short arm of the magnifying lever with its spherical head in contact with the face of the shoe J. Referring back to Fig. 2 it will be seen that one of the "circumferential" gauges is shown in position at L.

THAWING FROZEN GRAVEL IN PLACER MINING.

INTERESTING information regarding the use of water at natural temperatures for the purpose of thawing frozen gravel in placer mining operations is given in a Technical Paper 309,* by Charles Janin, consulting mining engineer, recently published by the United States Bureau of Mines. Experiments in cold water thawing demonstrate that under favourable conditions the process is an assured success. It is proving of great value to the gold-mining industry of Alaska and the Yukon Territory and is encouraging investigation and exploitation of areas of frozen gravel that had been considered of too low grade for profitable mining.

In placer mining in the far north one of the greatest difficulties encountered is the permanently frozen condition of the ground. In the early days of mining the ground was thawed by the primitive method of building wood fires on the surface, at the bottom of a shaft, or at the face of a drift. Although this method was slow and costly, a more effective one was not discovered until about 1898, when it was noticed that the steam escaping from the exhaust of a hoisting engine had thawed a hole in the solid "muck." Further experiments followed, and the direct application of steam through points proved so effective that it became the chief method adopted in thawing many millions of cubic yards of gravel for drift, surface mining, and dredging operations. Tests with hot-water thawing were also made at different times. Experiments indicated that ground could be thawed by this method, but in comparison with steam thawing the latter was generally found more effective. At all events, no extensive thawing with hot water was ever done.

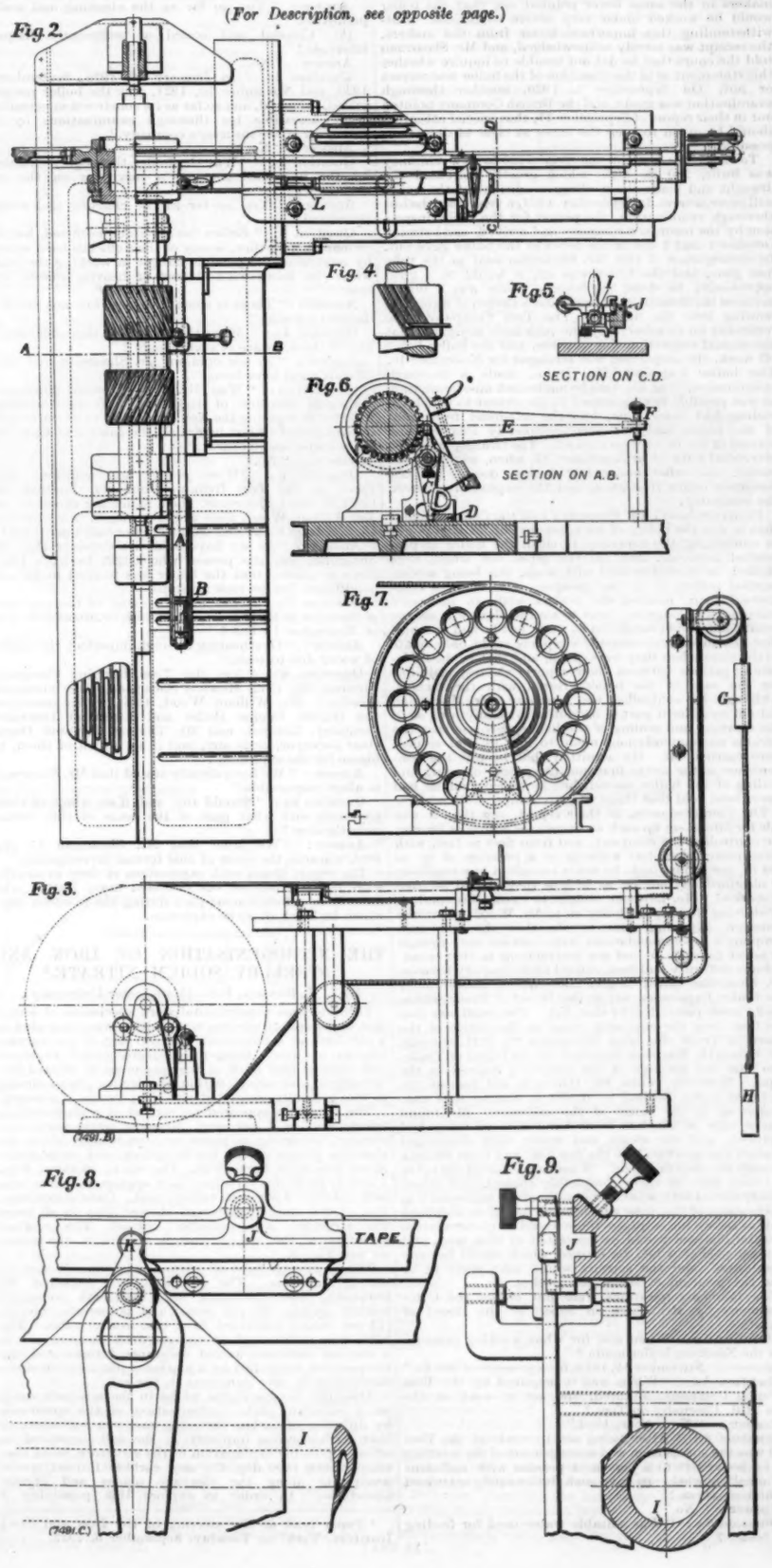
In all, many millions of cubic yards of frozen ground have been mined in the northern fields of Alaska and the Yukon Territory, as well as Siberia, by using various methods to soften or thaw the gravel. The most satisfactory method developed for many years was that of thawing with steam points. This method, however, proved slow and costly under the most efficient

* Copies of this paper can be obtained from the Bureau of Mines, Washington, D.C., U.S.A.

MACHINE FOR MEASURING GEAR TEETH.

CONSTRUCTED BY THE METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED.

(*For Description, see opposite page.*)



management, its cost amounting in general to about 40 per cent. of the total cost of mining, and at some mines to perhaps 70 per cent. to 80 per cent. The high cost of thawing required that the gravel mined contain a much higher gold content than ground that could be profitably mined where thawing was unnecessary, and prevented the working of the lower-grade ground in the frozen areas.

The working of most of the deeper frozen or partly frozen ground seemed enonomically impossible except where drift mining would be profitable. A number of gravel areas in the Far North have attracted mining men because of the high gold content as compared to dredgable areas of unfrozen ground in other districts. Little attempt to work much of this gravel has been made until recently, however, as no cheap method of thawing was known. Experiments have been made from time to time since the beginning of placer mining in the Far North with the purpose of developing a more efficient method of thawing the frozen ground, and the files of the Patent Office show drawings of some peculiar machines designed for that purpose.

About 1915 to 1917, different persons started experiments on an entirely new plan for thawing the frozen gravel. Water at the natural summer temperature was applied by drilling doles through the frozen muck and gravel to bedrock, and the water was allowed to find its way through the gravel back to the surface. This water was taken from surface ditches, or through pipes under pressure, or pressure was obtained by pumping. The results of these tests were very satisfactory.

Although there is still much to be learned regarding the practical application of the method, thawing with cold water has passed the experimental stage, and is being proved of great value to the gold-mining industry.

The successful application of this method where water is obtainable under pressure without pumping will make large areas of so-called low-grade ground available for dredging, and ground that has previously been considered to be of little or no value will now be of economic importance. Had the knowledge of this method of thawing been available to the Yukon Gold Company and other companies operating dredges in the Far North during the past ten years, there might have been a considerable saving in costs and a corresponding additional profit to those companies.

EXPLOSION OF A NESDRUM BOILER.

A FORMAL investigation has been made by the Board of Trade, under the Boiler Explosion Acts, 1882 and 1890, at the Council Chambers of the Town Hall, Stockton-on-Tees, on March 21, 22, 23, 24, 25, 27, 28 and 29, 1922, with regard to the cause and circumstances of an explosion of a boiler at the Tees Refining Company, Limited, Thornaby-on-Tees, Yorkshire, on November 13, 1921, by which a man was badly scalded, and died from the injuries received.

Mr. George C. Vaux appeared for the Board of Trade; Mr. C. B. Fenwick of Counsel, instructed by Mr. Reuben Cohen, solicitor, Stockton-on-Tees, for the Tees Refining Company, Limited, and Mr. Cecil Howard Shearman, their managing director; and Mr. C. H. Pickstone, solicitor, of Redcliffe, Lancashire, for the British Engine Boiler and Electrical Insurance Company, Limited, and Mr. Thomas Edward Dunn, their surveyor. Mr. William Wood, the works manager, appeared in person.

The "Nesdrum" boiler was of the water-tube type, constructed of steel, and consisted of a cylindrical steam and water drum 5 ft. internal diameter, placed horizontally, and three rows of top and bottom cylindrical headers, 2 ft. 2 in. internal diameter, each top and bottom header being connected by 19 generating tubes. Each row consisted of three sets of headers with their tubes arranged abreast of each other. Two of the rows were in front of the steam and water drum, the third row being at the back. The tubes and headers in the back row were placed vertically, and the front and second rows were inclined at an angle of approximately 27 deg. to the vertical. The top rows of headers were connected to each other and to the steam and water drum by nipples, and the bottom rows were similarly connected. The generating tubes and nipples were of seamless steel, the tubes being 3½ in. in external diameter No. 9 S.W.G. thick, and the nipples 3½ in. in external diameter and ⅜ in. thick. The tube and nipple ends were expanded into the plates and belled 15 deg. There was a manhole to the steam and water drum and to each of the headers. The blowing-down arrangement consisted of a parallel slide valve on the left rear bottom header connected by internal pipes to each of the other rear bottom headers.

The mountings consisted of:—
One pair of 2½-in. spring-loaded safety valves.
One 4-in. main stop valve.
One 4-in. superheated steam outlet valve.
One 2½-in. feed check valve.
One 2-in. blow-down valve.
One high and low water alarm valve.
Two water gauges.
One steam pressure gauge.

The boiler was constructed by Messrs. Richardsons, Westgarth and Co., engineers, Lower Commercial-street, Middlesbrough, in 1914, for the Tees Refining Company, Limited. Since its construction, repairs had been made consisting of replacing tubes choked with scale, blistered, or drawn out of shape. There was not sufficient evidence to fix the actual number of tubes replaced, but approximately 40 tubes were replaced at different times between the date of installation and the date of the explosion.

The boiler had been inspected by the inspectors of the Vulcan Boiler and General Insurance Company, Limited, Manchester, and the British Engine Boiler and

Electrical Insurance Company, Limited, Manchester, and by Mr. Lewis Taylor, the manager of the makers of the boiler.

Messrs. A. A. Hudson and James E. Wimshurst, Commissioners to the Board of Trade, in their report to the Assistant Secretary of the Board of Trade, state that the business of the company for which the boiler was required was the manufacture of bone-grease, tallow, glue, phosphoric acid, acid calcium phosphate, and chemical manures, including super-phosphates. Mr. Cecil Howard Shearman was the managing director of the company and practically controlled it after he became managing director in 1911. The boiler was purchased by him in 1914, and was thoroughly well made.

The boiler was required for continuous work night and day, but, the Commissioners state, this is not a type of boiler for such use. Boilers of this type are used by electrical companies for the rapid generation of steam when any great load of electricity is required at short notice. They are also used in ships, but the essential requirement in the use of such boilers is either that the water should be extremely pure so that the generating tubes do not become coated with scale, or that the boiler should be constantly put off work and the scale removed.

The boiler which exploded was used for long periods without any scaling, in fact, it was only scaled about once in twelve months, when thorough examinations were made by the insurance companies. It should have been scaled, as Mr. Shearman knew, at periods not exceeding two months. He was constantly informed by the insurance companies and by the makers of the boiler that it should not be used for such long periods without cleaning, but all the recommendations of the makers and of the insurance companies were disregarded.

Eventually, in the year 1921, the boiler had to be put off steam because a tube had given way, and the boiler was then found to be in a very bad condition. Two men were then set to work with the addition of a boy, one man working by night and one by day, and this went on until the British Engine Boiler and Electric Insurance Company, Limited, sent their inspector by appointment to make a thorough examination of the boiler on November 10, 1921. He then found that the boiler had been partly scaled, and that several tubes were choked with scale. He said when he left the works, "Get through the lot," meaning the remaining tubes which had not been cleaned, "and then there will be no doubt." The cleaning of the other tubes was then proceeded with, and this went on until the Sunday morning of November 13. At that time Mr. Shearman, finding another boiler in the works, a Kestner boiler, had practically broken down, ordered this boiler to be closed up, water put in, and the fires to be lighted, and that the scaling of the tubes, which was then only partly completed, should be seen to later when the Kestner boiler had been repaired and could be put to work again, and the Nesdrum boiler could be taken off work. Accordingly the fires were lit, the boiler put into work, and the explosion occurred about 8·30 of the same evening, severely injuring the fireman named Buttle, who died in hospital two weeks later.

Dealing somewhat more in detail with the recommendations which the makers chiefly made in letters to the Tees Company, and which the insurance companies made in their reports of thorough and working examinations of the boiler, the report states that the first recommendation appeared in printed instructions issued by the makers, and put on a wall just behind the boiler. One of these instructions was, "Clean boiler frequently and regularly (at least once a month if water is hard)." No notice was taken of this instruction, and on August 20, 1915, the makers wrote to the Tees Company a letter in which they said that the Nesdrum boiler should be taken off load as early as possible for cleaning and inspection purposes, adding "As you are aware it has now been on load for fully nine months day and night continuously, which is equivalent to eighteen months' ordinary work."

The result of this method of working was that on February 1, 1916, 15 new tubes had to be fitted. On August 8, 1916, the Vulcan Boiler and General Insurance Company, with whom the boiler was first insured, advised that: "Owing to the forced draught being so excessive as to burn out the mechanical stoker, this boiler be examined at an early date." It was examined on August 11, and this was the first time that the boiler was scaled since the last thorough examination on October 15, 1915. After the examination of August 11 1916, a certificate of thorough examination was issued in which the company said: "It is necessary this boiler be cleaned out at least monthly." That recommendation again, like all the recommendations of the insurance company, was entirely ignored. After several reminders from the company that it was necessary that the boiler should be cleaned out internally, and that the boiler was due for examination, it was not again cleaned out until November, 1917, and then for the purpose of a thorough examination. In the following year reminders were sent from time to time as to the necessity of cleaning the boiler, and at last, on June 19, 1918, the boiler was put off work, and 20 tubes were removed. Again, on November 17, 1918, Mr. Shearman was reminded that the boiler should not be worked longer than 1,000 hours without being opened out for tube cleaning, but the recommendation was again disregarded. In May, 1919, the Tees Company ceased to insure with the Vulcan Company, and placed the insurance of the boiler with the British Engine Boiler and Electric Insurance Company, Limited. The boiler was prepared for a thorough examination, which was made in January, 1920. This was fourteen months (less four days) since the previous examination, and during the whole of that time the boiler had never been scaled, and, except for short intervals, had been worked night and day.

On August 31, 1920, the makers wrote to the Tees Company, saying: "The average scale is about ¾ in. thick. This state is entirely due to neglect, as the boiler has never been properly cleaned since it was installed in 1914. The waste of coal is, of course, very heavy, due to the scale inside and the soot outside." At that time a Whitehead's patent furnace was supplied, and the makers in the same letter pointed out that the boiler would be worked under very severe conditions. Notwithstanding this important letter from the makers, the receipt was merely acknowledged, and Mr. Shearman told the court that he did not trouble to inquire whether this statement as to the condition of the boiler was correct or not. On September 1, 1920, another thorough examination was made, and the British Company pointed out in their report of September 21, that special attention should be given to keep the tubes as clear of deposit as possible.

Towards the end of the year 1920 a new chimney was built, 200 ft. high, which greatly increased the draught and made the working conditions of the boiler still more severe. In September, 1921, a year after the last thorough examination, the period for the boiler inspection by the insurance company had arrived, and between October 1 and 3 one of the tubes in the boiler gave out. In consequence of this Mr. Shearman said as the tube had gone, and the boiler was off, it would be a good opportunity to clean the boiler. There was a blister in one of the front nests of tubes and a stream of water was pouring into the fire-box. The Tees Company were reminded on October 7 by the insurance company that the annual inspection was overdue, and the boiler being off work, the inspection was arranged for November 10. The boiler inspector, Mr. Dunn, made a thorough examination, or at any rate he made such an examination as was possible having regard to the extent to which the scaling had been done, but the left-hand front nest of the boiler had not been completely cleaned, and several of the tubes were choked. The cleaning was then proceeded with until November 13, when, as previously stated, the other boiler had broken down, and the Nesdrum boiler re-started, and the explosion occurred the same day.

In his evidence, Mr. Shearman told the Commissioners that it was the policy of his company, or his own policy as controlling the company to clean the boiler at protracted intervals, and cut the pipes out which were choked, or thickly coated with scale, this being a commercial policy, as it was cheaper. He, being a commercial man, insured the boilers with an insurance company and expected them to see the plant was always in safe and proper condition to work, but he had to admit that the insurance company's reports could only relate to the time when they were given, and that in the intervening periods between these reports the responsibility for the care of the boilers rested with the owners. Although he controlled the company, Mr. Shearman did not consider it part of his duties to do anything as to the cleaning and scaling of the boiler or to see that the various recommendations made to him in that respect were carried out. He admitted that he put the convenience of the works first and the proper cleaning and scaling of the boiler second, but he added that he had never been told that there was any danger from scale.

The Commissioners, in their report, say that it was idle for him to set up such an excuse for acting as he did. He controlled the company, and from first to last, with these powerful boilers working at a pressure of up to 200 lb. per square inch, he never consulted any engineer, or obtained any advice, as to how they should be used or worked. He, however, sought to excuse his conduct by shifting the responsibility on to Mr. Wood, the works manager, expecting him to see that the insurance company's recommendations were carried out, though he never gave Mr. Wood any instructions to that effect.

Some difficulty had been caused in the inquiry because Mr. Shearman failed to give the required notice under the Boiler Explosions Act to the Board of Trade within the 24 hours prescribed by that Act. The result was that the first time the explosion came to the notice of the Board of Trade was after November 29, 1921, through Mr. Huworth, Engineer Surveyor to the Board of Trade, who saw the account of the coroner's inquest in the paper. However, when Mr. Huworth did inspect the exploded boiler, he had no doubt in coming to a conclusion as to the cause of the explosion. He found that a tube in the left front hand nest of tubes had ruptured, and the steam and water were discharged through the aperture into the fire-box, and from the box through the open fire-door. When he examined the tubes he found some of them completely choked, and others thickly coated with scale. The cause of the explosion was overheating of the tube which burst owing to stoppage in it, as below the stoppage there would be no circulation of water; steam would be generated at that spot, and a steam pocket would be formed which would become superheated, and the rupture would take place at or near the position of the steam pocket.

The following questions were put before the Commissioners by Mr. Vaux on behalf of the Board of Trade:—

Question 1: "When and for what working pressure was the Nesdrum boiler made?"

Answer: "November 19, 1914, for a pressure of 200 lb."

Question 1A: "When was it acquired by the Tees Refining Company, Limited, and set to work at the Tees Mill, Thornaby-on-Tees?"

Answer:—"November, 1914."

Question 2: "After being set to work at the Tees Mill was the supervision and management of the working of the boiler left to a person or persons with sufficient technical knowledge to have such duties safely entrusted to him or them?"

Answer: "No."

Question 2A: "Was suitable water used for feeding the boiler?"

Answer: "Yes."

Question 2B: "Was the boiler periodically inspected by a competent person or competent persons?"

Answer: "Yes."

Question 2C: "Was the boiler properly (*a*) examined internally?"

Answer: "Yes, so far as the cleaning and scaling permitted."

(*b*) "Cleaned and scaled at sufficiently frequent intervals?"

Answer: "No."

Question 3: "On January 16, 1920, September 1, 1920, and November 10, 1921, was the boiler properly scaled, prepared, and so far as its construction permitted, made accessible for thorough examinations by the surveyors of the insurance company."

Answer: "No."

Question 3A: "Was the boiler thoroughly examined by the insurance company's surveyors on the said occasions?"

Answer: "Yes, so far as the cleaning and scaling permitted."

Question 4: "Before the explosion occurred, had the owners of the boiler, or any of their officials been warned by anyone of the possible danger in working the boiler when the tubes were choked or heavily coated with scale?"

Answer: "There is some evidence, but not much of distinct warning."

Question 4A: "Were the owners or their officials, or any of them, aware of such danger?"

Answer: "In our opinion, Mr. Shearman and other officials must have been."

Question 5: "Was Mr. Cecil Howard Shearman, managing director of the Tees Refining Company, justified in ordering the Nesdrum boiler to be set to work on November 13 last before all the tubes had been properly scaled and cleaned?"

Answer: "No."

Question 6: "Were proper and sufficient steps taken by the Tees Refining Company, Limited, Mr. Cecil Howard Shearman, their managing director, and Mr. William Wood, their works manager, to ensure that the Nesdrum boiler was worked under safe conditions?"

Answer: "As we have said, we consider that Mr. Shearman was the person who ought to have taken steps to ensure that the boiler was worked under safe conditions, but he took no steps."

Question 7: "What was the cause of the explosion of the tube in the Nesdrum boiler at, or about 8.30 p.m. of November 13 last?"

Answer: "Overheating through imperfect circulation of water due to scale."

Question 8: "Are the Tees Refining Company, Limited, Mr. Cecil Howard Shearman, their managing director; Mr. William Wood, their works manager; the British Engine Boiler and Electrical Insurance Company, Limited, and Mr. Thomas Edmund Dunn, their surveyor, or is any, and if so, which of them, to blame for the explosion?"

Answer: "We have already stated that Mr. Shearman is alone responsible."

Question 8A: "Should any, and, if so, which of them pay any, and what part of the costs of this formal investigation?"

Answer: "We order that Mr. Shearman do pay 400*l.* towards the costs of this formal investigation."

The report closes with expressions of deep sympathy with the relatives of the deceased man, Buttle, who must have suffered great pain during the fourteen days which he lived after the explosion.

THE NITROGENISATION OF IRON AND STEEL BY SODIUM NITRATE.*

By L. E. BENSON, B.Sc. (Manchester University).

DURING some experimental work specimens of armco iron and steels of varying composition were annealed in a salt-bath at a temperature of 500 deg. C. for varying lengths of time. Subsequent microscopical examination showed that most of the specimens so treated had developed a structure within the ferrite grains similar to that generally associated with the presence of nitrogen.

The structure appeared to consist of a dark-etching (picric acid or 1 per cent. alcoholic nitric acid) constituent, occurring as plates or lines usually along the cleavage planes of the ferrite grains, and occasionally along the grain boundaries. The micro sections, Figs. 1 and 2, show this structure as it appears in armco iron and a plain 0·4 per cent. carbon steel. Careful examination of the original materials showed that in all cases the structure was perfectly normal. The original structure of the armco iron is shown in the micro section Fig. 3.

The specimens were all normalised from 950 deg. C. before annealing. The annealing was effected by immersing the specimens in a salt-bath composed sodium nitrate (85 per cent.) and potassium chloride (15 per cent.) contained in a cast-iron crucible. The bath was maintained at the required temperature in a vertical nichrome-wound resistance furnace and the temperature controlled by a platinum platinum-rhodium thermocouple, also immersed in the salt.

Although the specimens whilst in the salt-bath stood on a porcelain plate, carburisation of the specimens by diffusion of carbon from the cast-iron container, or from carbonaceous impurity in the salt, appeared to afford a possible explanation of the structure, as at that temperature (500 deg. C.) any carbide formed would precipitate along the cleavage planes and crystal boundaries. In order to explore this possibility a

* Paper read at the meeting of the Iron and Steel Institute, York, on Tuesday, September 5, 1922.

specimen of the normalised armco iron was annealed for 2½ hours at the same temperature in a bath of recrystallised sodium nitrate contained in a porcelain crucible. As a result of this treatment the iron was found to have developed the nitride structure to an average depth of 0·2 mm. from the surface.

To obtain positive evidence of nitrogenisation both unannealed and annealed specimens of armco iron were analysed for nitrogen. The determinations were made colorimetrically, on 1 gramme of filings, by means of Nessler's reagent, after distillation from a strongly alkaline solution. By carefully standardising the conditions of the determinations very consistent results were obtained.

A sample of armco iron before annealing was found to contain less than 0·002 per cent nitrogen. A specimen annealed for 10 hours was observed under the microscope to exhibit the nitride structure to an average depth of 0·4 mm. Approximately 1·5 mm. was filed off all the faces of this specimen and the filings collected. A further 1 mm. was then filed off. The nitrogen content of the three samples was found to be as follows :—

	Per Cent. Nitrogen.
Outer layer	0·036
Intermediate layer	0·004
Core	0·002

From these determinations it would appear that the specimens in question had become nitrogenised through being annealed at a temperature of 500 deg. C. in a salt-bath containing sodium nitrate.

Referring to the last-mentioned nitrogen determination, since the depth of metal filed off in the first instance and the depth of penetration of nitrogen are in the ratio of nearly 4 to 1, it can be assumed that 0·036 per cent. is certainly much lower than the maximum concentration of nitrogen obtained: and since, according to Andrew, 0·3 per cent. of nitrogen is sufficient to suppress the critical change points, there must have been a high enough concentration of nitrogen in the outer layers to exert a considerable influence on the physical and other properties of the material.

Rate of Penetration of Nitrogen in Iron and Some Steels.—As sodium nitrate is frequently the chief constituent of salt-baths for low-temperature heat treatment, it was thought advisable to investigate how far nitrogenisation was likely to affect iron and steels under varying conditions. The influence of time on the rate of penetration of nitrogen in armco iron has been investigated up to 80 hours, and in various steels up to 20 hours.

The composition of the materials used in this investigation is given in Table I.

The procedure was to etch a cross-section of each specimen and examine microscopically on a Zeiss photomicrographic apparatus. The average depth to which nitrogen had penetrated in sufficient concentration to form nitride plates was marked on the ground glass screen and measured by substituting an engine divided scale $\left(\frac{1 \text{ mm.}}{100}\right)$ in place of the specimen. In general, the penetration was observed to be very uniform, and only in a very few cases was any difficulty experienced in arriving at a fair estimate of the average depth. The results of the penetration measurement will be found in Table II.

The results with regard to armco iron are plotted graphically in Fig. 4. Penetration of the nitrogen is comparatively rapid during the first few hours, but after 15 to 20 hours the rate remains practically constant at 0·02 mm. per hour.

The rate of penetration of nitrogen in steel in general appears to be considerably slower than in pure iron.

TABLE I.—*Analyses of the Materials.*

Sample.	Mark.	Carbon Per Cent.	Manganese Per Cent.	Silicon Per Cent.	Sulphur Per Cent.	Phosphorus Per Cent.
Armco iron ..	A	Guaranteed purity 99·84 per cent.				
Pure carbon ..	B	0·16				
Crucible	C	0·37	0·12	0·05	0·03	0·025
Steels	D	0·58				
Open-hearth steel	E	0·41	0·54	0·12	0·07	0·04
Acid Bessemer steel	H	0·40	0·89	<0·08	0·06	0·06

In Fig. 5 the influence of time on the rate of penetration of nitrogen in the pure carbon steels is graphically represented, from which it is apparent that the rate of penetration of nitrogen in iron is seriously influenced by the presence of carbon, the rate being lowered as the carbon content rises.

That the presence of pearlitic areas in the ferrite should impede the diffusion of nitride seems only natural, but the retardation produced by only 0·16 per cent. carbon as compared with that produced by 0·37 per cent. and 0·58 per cent. carbon seems sufficiently great to suggest that possibly influences other than merely the presence of pearlitic areas have contributed, and a greater solubility of carbide in alpha iron than has generally been supposed to exist might be expected to affect the rate of penetration thus.

Manganese would appear to exert a more profound influence on the rate of penetration than does carbon. Ample evidence of this fact is afforded by the time penetration curves for the three steels with varying manganese content (Fig. 6). This is in accordance with Tschischewski's observations on the nitrogenisation of iron manganese alloys.*

The curve for the steel containing 0·4 per cent. carbon and 0·54 per cent. manganese is identical with that for the pure 0·6 per cent. carbon steel, but in the case of the acid Bessemer steel containing 0·89 per cent. manganese the penetration was very slight indeed. Even after 20 hours' annealing the nitride structure was only observable in the outermost layers.

FIG. 1. NITRIDE NEEDLES IN ARMCO IRON. × 600.

FIG. 2. NITRIDE NEEDLES IN STEEL. × 400.

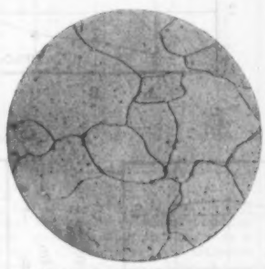
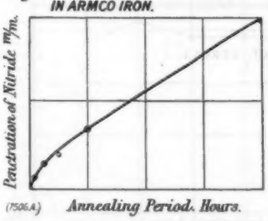
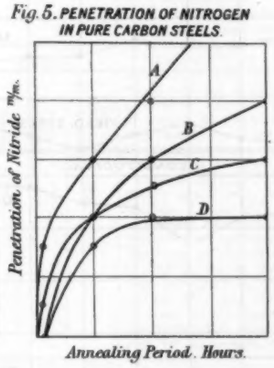


FIG. 3. ARMCO IRON BEFORE ANNEALING. × 600.





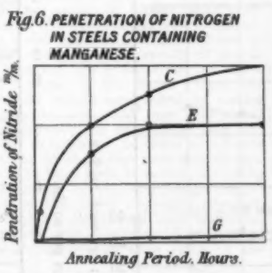


TABLE II.—*Penetration of Nitrogen in Millimetres.*

Time of Annealing.	A.	B.	C.	D.	E.	H.
Normalised ..	0·00	0·00	0·00	0·00	0·00	0·00
1 hour	0·15	0·00	0·05	0·00	0·00	0·00
5 hours	0·30	0·20	0·20	0·15	0·15	
10 hours	0·40	0·30	0·25	0·25	0·20	very
20 hours	0·70	0·40	0·30	0·20	0·20	slight
80 hours	2·00	..	..	..	..	..

* ENGINEERING, vol. c, page 330 and vol. ci, pages 171 and 217.

Dissociation of Iron Nitride.—Tschischewski has found that above 450 deg. C. nitride of iron is unstable, and in this connection it is of interest that a piece of armco iron 0·5 cm. thick, nitrogenised to such an extent that the characteristic needles could be observed almost to the centre of the mass, after heating in an open muffle for 90 minutes at approximately 700 deg. C. showed no signs at all of nitride structure, and on analysis the nitrogen content was found to be only 0·0025 per cent.

Lines along which further investigation might be carried out suggest themselves, but the opportunity for this work has not so far arisen.

The work in connection with this paper was carried out with the assistance of a Simon-Carves Industrial Research Scholarship.

CATALOGUES.

Surveying Instruments.—A revised price list with references to their catalogue of surveying instruments has been issued by Messrs. T. Cooke and Sons, Limited, York.

Steam Packings, &c.—A four-page catalogue from Messrs. Lancaster and Tonge, Limited, Pendleton, Manchester, illustrates their metallic rod packings, piston rings and steam traps.

Bundling Press.—An illustrated catalogue giving prices and particulars of their bundling press for waste paper, has come to hand from Messrs. Hollings and Guest, Limited, Thimble Mill-lane, Birmingham.

Electrical Apparatus.—The Westinghouse Electric and Manufacturing Company, East Pittsburg, U.S.A., send copies of catalogues of motor starters and of a dry type electrically-heated glue pot with rheostatic control.

Electric Apparatus.—A catalogue of automatic circuit breakers (air break) and price lists of lightning arresters and hand-operated starting and regulating rheostats have been received from the British Thomson-Houston Company, Limited, Rugby.

Ferro-Concrete Construction.—Many examples of their ferro-concrete work in foundations, buildings, culverts, bridges, tanks and other structures are illustrated and described in a catalogue issued by Messrs. K. Holst and Co., 1, Victoria-street, London, S.W. 1.

Air Compressors.—A catalogue of air compressors in a considerable range of standard sizes, portable compressor sets, desiccating plants, hand-operated compressors and pneumatic hoists is to hand from Messrs. W. H. A. Robertson and Co., Limited, Bedford.

Pig Breaker.—The Temple-Cox pig breaker supplied by United Brass Founders and Engineers, Limited, Cornbrook, Manchester, is dealt with in a catalogue received from this firm. We illustrated and described this appliance on pages 782 and 811 of our last issue.

Bulkhead Doors.—A very interesting description of the construction and operation of watertight bulkhead doors, with numerous illustrations, is given in a special catalogue issued by Messrs. Brunton Brothers, Limited, 17, St. Stephen's House, Victoria Embankment, London, S.W. 1.

Telephone Apparatus.—Apparatus for private branch telephone exchanges, which the Post Office now instal, made by the Relay Automatic Telephone Company, Limited, Marconi House, Strand, London, W.C. 2, is described and illustrated in a special catalogue recently issued by that firm.

Primary batteries.—Primary cells and batteries, both wet and dry, for supplying the comparatively high potential required for the plate circuits of valves used in wireless apparatus are dealt with in a catalogue received from Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E.18.

Pure Iron.—The qualities and special uses of ingot iron of 99·84 per cent. commercial purity, made by the Shelton Iron, Steel, and Coal Company, Limited, are described in a catalogue received from Messrs. Tyer & Co., Limited, Ashwin-street, Dalston, London, E.8. This material is especially useful for wire and similar products and is highly resistant to corrosion.

Pumps.—A catalogue of small semi-rotary pumps, with single, double and quadruple action, and with pipe connections ranging from ¼ in. to 4 in. in diameter, has come from United Brassfounders and Engineers, Limited, Cornbrook, Manchester. These pumps are British made, in various materials, and the catalogue, which is fully illustrated, includes priced lists.

Explosives.—The application of explosives, such as dynamite and gelignite, to the breaking up of scrap castings, boilers, plates, concrete, shipwrecks, and also to river deepening, well sinking and other industrial operations, is well described, with some general technical information, in a new pamphlet issued by Nobel Industries, Limited, Buckingham-gate, London, S.W. 1.

Plastic Wood.—As already described in these columns, a preparation of wood capable of being moulded in its plastic state, and after it has hardened, of being turned or cut with ordinary woodworking tools, is manufactured by Neool Industrial Collodions, Limited, 62, London Wall, London, E.C.2. The material is dealt with in a pamphlet received from this firm.

Turbo-Blowers.—A description of their blowers for delivering large volumes of air at moderate pressures (*i.e.*, from 10 lb. to 16 lb. per square inch) is given in a catalogue issued by the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 2. The illustrations of a complete machine and separate parts are excellent, and there is an interesting record of a series of tests giving readings at inlet and discharge and the volume and pressure of air delivered.

THE EFFECTS OF OVER-HEATING AND REPEATED MELTING ON ALUMINIUM.*

By W. ROSENHAIN, D.Sc., F.R.S., Vice-President, and J. D. GROGAN, B.A., Member (Teddington). (From the National Physical Laboratory.)

THIS paper forms part of a research carried out for the Engineering Research Co-Ordinating Board, Aeronautics Research Committee (Materials and Chemistry Sub-Committee), who have granted permission for the present publication. The research constitutes a continuation of the systematic study of aluminium and its alloys, which has long been in progress in the Metallurgy Department of the National Physical Laboratory.

The work described in this paper was undertaken in order to ascertain whether certain forms of treatment in the melting and re-melting of aluminium would bring about in the metal deterioration approximating to the condition generally described as "burnt" aluminium. It has frequently been stated that exposure to an unduly high temperature during melting, and also repeated re-melting of the same metal, even at ordinary melting temperatures, brings about such deterioration. Both kinds of treatment were accordingly tried.

Material Used.—The material used has been mainly commercial aluminium of the highest obtainable purity, approximating to an aluminium content of 99·65 per cent. The content of silicon and iron was approximately 0·16 per cent. of each element. Some experiments were made also with aluminium containing 0·77 per cent. of iron and 0·72 per cent. of silicon. The latter material was made by adding iron-aluminium and silicon-aluminium to aluminium containing 0·23 per cent. each of iron and of silicon.

Effect of High Melting and Casting Temperatures.—For the purpose of this series of experiments the aluminium was melted in a Morgan electric tilting crucible, temperatures of 700 deg., 800 deg., 900 deg. and 1,000 deg. C. being used. No attempt was made to control the atmosphere of the furnace, which therefore consisted of atmospheric air from which a certain proportion of oxygen would be removed by combination with the surface layer of the aluminium. Fresh oxygen however, would probably diffuse into the air space of the crucible through the various openings and crevices. A small amount of carbon derived from the crucible would also undergo oxidation during the melting process, and a certain amount of carbon monoxide and carbon dioxide would probably be present in the atmosphere above the aluminium. It should be mentioned, however, that the molten aluminium was not in contact with the carbonaceous material in the crucible, being isolated from it, both chemically and electrically, by a thin layer of fireclay. In some experiments, the clay lining was painted over with ordinary aluminium paint. This, when the crucible became heated, was oxidised and provided a thin but very strongly adherent coating of alumina on the inside of the crucible. In any case, however, there was no appreciable attack upon the clay lining by the molten metal or its oxide.

The whole of the experiments in each series were carried out with a single batch of metal, a quantity sufficient for the whole series being melted in the crucible in the first instance. When the lowest temperature at which a test was to be made had been reached, the castings required for test in regard to that temperature were poured, the crucible tilted back to the vertical, and the temperature raised until the next temperature for a test was attained, and so on until the highest temperature had been reached. It will thus be seen that the metal, which was finally cast at 1,000 deg. C., had been disturbed by the casting of the previous test-pieces, at 900 deg., 800 deg. and 700 deg. C.

At each of the temperatures indicated four 1 in. diameter chill-cast bars were poured, and also a small ingot which was allowed to solidify in an open trough-shaped iron mould. Each of these small ingots weighed from 550 grammes to 600 grammes. The object in making these particular castings was in the first place to provide material for tensile test-pieces, and in the case of the ingot, to observe the character of the surface after solidification and also by subsequent cutting of the ingot, polishing and macro-etching to study the effects of the casting temperature upon the crystalline structure of the material.

For the purpose of testing the quality of the material cast at each temperature, it was thought undesirable to rely upon tensile tests of the material in the cast condition. Not only is cast aluminium very weak, but any slight unsoundness in a casting of this kind would produce a disproportionately large effect. The chill-cast bars, 1 in. in diameter, were accordingly heated to 450 deg. C. and forged under the hammer until they formed flat slabs about ¾ in. thick. These were then rolled at the same temperature into strips 0·1 in. thick. From these strips tensile test-pieces were cut and tested, after annealing for 30 minutes at 450 deg. C. It was thought desirable to apply this annealing treatment in order that all the test-pieces should be in as nearly as possible a corresponding condition; otherwise, slight differences in temperature and time of rolling might have affected the results appreciably.

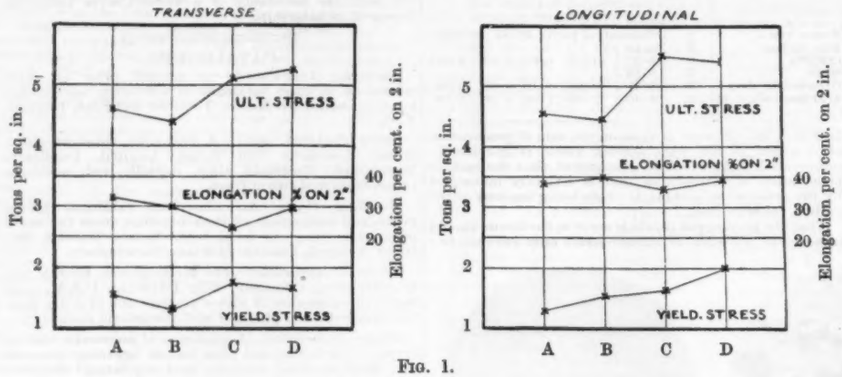
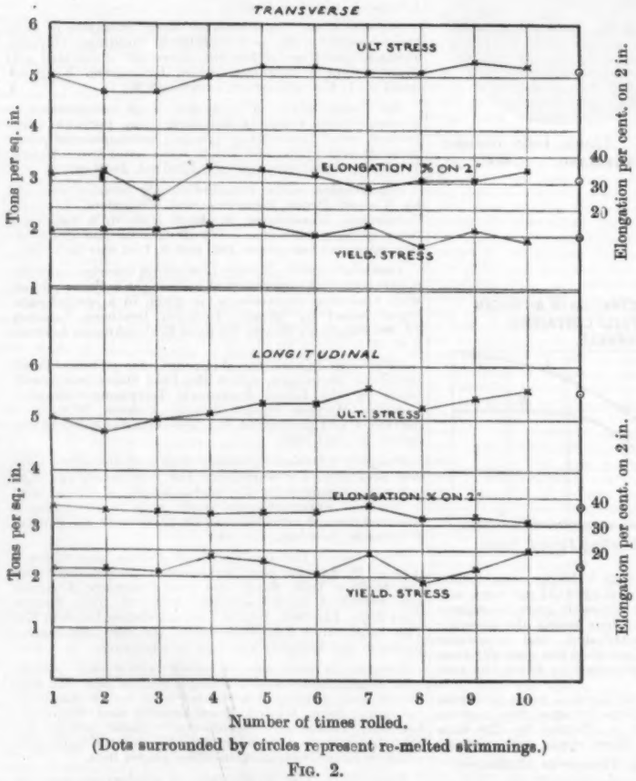
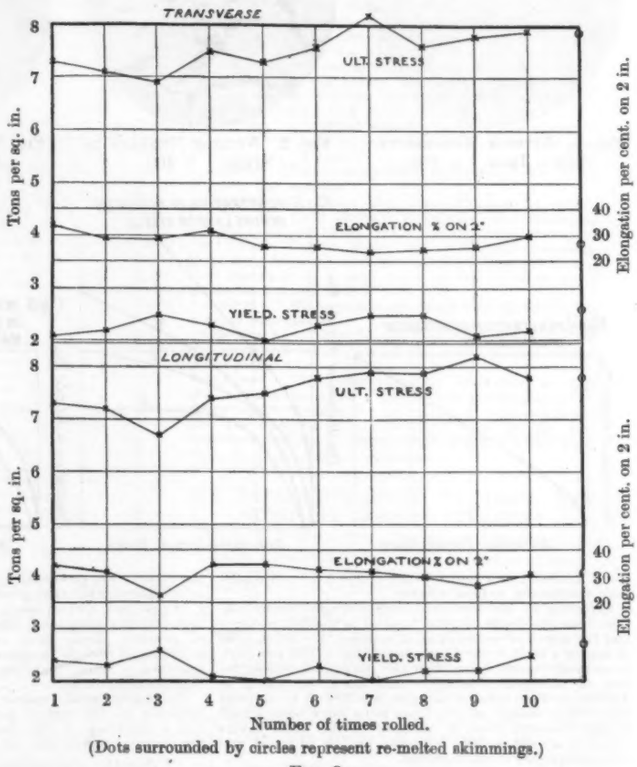


FIG. 1.



(Dots surrounded by circles represent re-melted skimmings.)

FIG. 2.



(Dots surrounded by circles represent re-melted skimmings.)

FIG. 3.

The results of tensile tests on these rolled strips are shown in the following table:—

TABLE I.—*Thickness of Sheet, 0·1 in.*

Pouring Temperature.	Yield Stress.	Ultimate Stress.	Elongation per Cent. on 2 in.
700 deg. C.	1·6	4·9	42
800 deg. C.	1·7	4·8	39
1,000 deg. C.	1·8	4·8	42

Yield stress and ultimate stress in British tons per square inch.

As will be seen from the above table, there is no evidence of any serious deterioration in the quality of the metal even when a casting temperature as high as 1,000 deg. C. has been used. The only anomalous result which was found throughout the series was given by test-pieces from one set of bars cast at 700 deg. and 800 deg. C. These gave abnormally low results for the

* Paper read at the meeting of the Institute of Metals, Swansea, on Thursday, September 21, 1922.

ultimate stress. On repetition, however, perfectly normal results were obtained and the latter have been included in the table, the abnormally low results being regarded as due to some accidental cause. In any case, the samples in question were cast at something like normal temperatures, so that defects in them could not be ascribed to overheating or burning.

The evidence derived from the tensile tests tabulated above has been confirmed by the examination of the small ingots. The appearance of the air surface of these ingots showed no systematic difference corresponding to the increasing casting temperature. The macrostructure was also very similar throughout, except that there was a distinct increase of crystal size with increasing casting temperature.

Effect of Prolonged Heating at a High Temperature on Aluminium.—The material used was similar to that employed in the previous series of experiments (99·65 per cent. aluminium). Sufficient metal for the whole series was again melted in the Morgan electric tilting crucible. When it was melted and a temperature of 720 deg. C. had been reached, some metal was withdrawn into a previously heated crucible serving as a ladle and cast in a slab mould ½ in. by 12 in. by 5 in. (slab A). The rest of the metal was heated to 1,000 deg. C. and held between 900 deg. C. and 1,000 deg. C. for 1 hour. More metal was then withdrawn at 930 deg. C. into a heated crucible. When it had cooled to 720 deg. C. the metal was skimmed and cast in a slab mould as before (slab B). The rest of the charge was heated for three more hours at a temperature of 1,000 deg. to 1,100 deg. C., and was then withdrawn at 1,030 deg. C. into a heated crucible. One slab was cast at once from this metal (slab C). The rest was allowed to cool to 720 deg. C., and was then cast after skimming (slab D).

The metal in the furnace was never deliberately stirred, and was only disturbed when a charge was withdrawn and when a thermocouple was inserted to determine the temperature. During the heating at 1,000 deg. to 1,100 deg. C. the metal became contaminated to a small extent by solution of a short length of the nickel-chromium couple-wire used. Of the four slabs obtained all appeared satisfactory on visual examination except slab C (poured at 1,000 deg. C.). This had a very rough uneven surface.

All four slabs were rolled at 450 deg. C. down to a thickness of 0·05 in., and gave a sheet free from surface defects except that from slab C. This slab developed on rolling a line of holes, probably due to contraction cavities in the casting. The surface was also considerably blistered all over.

Transverse and longitudinal test-pieces were cut from each sheet and tested after annealing for 30 minutes at 450 deg. C., with the following results :—

TABLE II.

No.	Treatment.	Longitudinal.			Traverse.		
		Yield Stress.	Ultimate Stress.	Elongation per Cent. on 2 in.	Yield Stress.	Ultimate Stress.	Elongation per Cent. on 2 in.
A	Normal ..	1·3	4·5	38	1·5	4·5	33
B	Heated to 900 deg. C. to 1,000 deg. C. for 1 hour; poured at 720 deg. C.	1·5	4·4	40	1·3	4·4	30
C	As B, then heated for 3 hours to 1,000 deg. to 1,100 deg. C.; poured at 1,000 deg. C.	1·6	5·4	36	1·7	5·0	23
D	As C; poured at 720 deg. C.	2·0	5·4	39	1·6	5·2	29·5

British tons per square inch. The results are also shown graphically in Fig. 1.

The aluminium does not appear to have been damaged permanently by the treatment to which it has been submitted. Even the slab poured at 1,000 deg. C. gave sheet the elongation of which is quite high. It is probable that the increase in yield stress and ultimate stress, shown by this sheet and sheet from the slab D cast after it, is due to the small quantities of nickel and chromium introduced by the thermocouple.

It is evident from the results given above that if aluminium of high purity is heated in an atmosphere consisting almost entirely of air, no serious deterioration occurs even at temperatures as high as 1,000 deg. C. It remains to be seen by further investigation whether these conclusions must be modified if the atmosphere contains furnace gases, and if the aluminium itself contains larger proportions of impurities. So far as oxidation is concerned, however, the present experiments indicate clearly that the part which it is supposed to play has in the past been considerably exaggerated.

EFFECT OF REPEATED ROLLING AND RE-MELTING OF ALUMINIUM. SERIES 1 AND 2.

Material Used.—The material used was aluminium of the highest grade (99·65 per cent. aluminium) for Series 1, and lower grade aluminium containing iron 0·77 per cent. and silicon 0·72 per cent. for Series 2.

Series 1.—The metal was melted in a Salamander crucible in a gas-fired furnace, the initial weight of metal being about 22 lb. The metal was cast at a normal working temperature (720 deg. C.). The material cast consisted of two slabs ½ in. by 12 in. by 5 in., and two small ingots similar to those already described. The slabs were rolled at a temperature of 450 deg. C. to a thickness of 0·05 in. From the sheet thus produced sufficient was cut for the preparation of tensile test-pieces, and the remaining sheet was cut up, annealed at 450 deg. C., rolled to 0·01 in. and re-melted. For the purpose of re-melting, the small ingots were introduced into the empty crucible, allowed to melt, and the thin sheet was pushed into the molten metal. When all the charge had melted it was carefully skimmed and further slabs and ingots poured. In all, this operation of rolling and re-melting was carried out ten times. From each sheet of 0·05 in. thickness, both transverse and longitudinal test-pieces were cut and broken in the testing machine after being annealed for 30 minutes at 450 deg. C. It may be said at once that there was no appearance of deterioration in the quality of the sheet so far as surface character was concerned. There was no sign of any increase in surface defects after successive re-melting. The results of tensile tests are tabulated in Table III, and are graphically represented in Fig. 2.

TABLE III.—*Thickness of Sheet, 0·05 in.*

No. of Times Rolled.	Longitudinal.			Transverse.		
	Yield Stress.	Ultimate Stress.	Elongation per Cent on 2 in.	Yield Stress.	Ultimate Stress.	Elongation per Cent on 2 in.
1	2·1	5·0	37	2·1	5·0	33
2	2·1	4·7	36	2·1	4·7	34
3	2·1	4·9	34	2·1	4·7	24
4	2·4	5·0	34	2·2	5·0	36
5	2·3	5·2	35	2·2	5·2	35
6	2·0	5·2	35	2·0	5·2	33
7	2·4	5·5	38	2·2	5·1	28
8	1·9	5·1	32	1·8	5·1	31
9	2·1	5·3	33	2·1	5·3	31
10	2·0	5·5	31	1·9	5·2	35
Re-melted skimmings	2·2	5·0	37	2·0	5·1	31

British tons per square inch.

It will be seen from the data given in the table and represented in Fig. 2 that there is no systematic change in the properties of the metal, except that there is a slight degree of hardening, in the sense that the ultimate stress increases by a very small amount. This is not, however, compensated by any systematic decrease in the elongation, while the yield stress, which is somewhat indefinite in these circumstances, does not appear to vary appreciably.

In order to ascertain whether possibly deteriorated metal had been removed into the skimmings which formed an appreciable percentage of the total amount of metal at the end of a long series of re-meltings, these skimmings were charged into a crucible together with a small amount of flux, consisting of cryolite 60 per cent., potassium chloride 40 per cent. A considerable yield of metal (94 per cent. of the skimmings) was obtained, and this was cast into a slab rolled to 0·05 in. and tensile tests made on the sheet obtained. The results of tensile tests made on this material are quite equal to those obtained throughout the rest of the series. They are shown graphically by the points surrounded by circles in Fig. 2. It will thus be seen that even the metal extracted by re-melting from the skimmings had not deteriorated appreciably in quality. In order to indicate the scale of loss of metal in these repeated re-meltings, it may be stated that the final yield of metal, including that obtained by re-melting of the skimmings, represented 87·5 per cent. of the metal originally charged. In view of the fact that the metal had been re-melted ten times, this shows that only a very small amount of loss by oxidation had occurred at each stage of the operation.

Series 2. *Material Used.*—In this series aluminium containing 0·77 per cent. of iron and 0·72 per cent. silicon was used, the treatment being the same as that of Series 1. The results obtained are tabulated in Table IV, and are shown graphically in Fig. 3.

TABLE IV.

No. of Times Rolled.	Longitudinal.			Transverse.		
	Yield Stress.	Ultimate Stress.	Elongation per Cent. on 2 in.	Yield Stress.	Ultimate Stress.	Elongation per Cent. on 2 in.
1	2·4	7·3	34	2·1	7·3	34
2	2·3	7·2	32	2·2	7·1	29
3	2·6	6·7	23	2·5	6·9	29
4	2·1	7·4	35	2·3	7·5	32
5	2·0	7·5	35	2·0	7·3	26
6	2·3	7·8	33	2·3	7·6	26
7	2·0	7·9	32	2·5	8·2	24
8	2·2	7·9	30	2·5	7·6	25
9	2·2	8·2	27	2·1	7·8	26
10	2·5	7·8	31	2·2	7·9	30
Re-melted skimmings	2·7	7·8	31	2·6	7·9	27

British tons per square inch.

As in the previous experiments, the variations in the figures are not systematic, and the material remaining at the end of the series is not appreciably different in tensile strength and elongation from that used at the beginning.

These experiments appear to indicate clearly that even when the aluminium has been reduced to a form in which a very large surface is exposed to atmospheric oxidation, repeated re-melting does not appreciably affect the quality of the metal. This is in striking contradiction to the views which have been current in the aluminium industry hitherto, and naturally suggest the comparison of the conditions under which re-melting occurs in industrial practice and in the laboratory experiments here described. There appears to be little or no difference in the actual method of melting, casting, or rolling which could have any appreciable effect upon the quality of the metal, except perhaps in so far as soundness and freedom from defects are concerned. On the other hand, in the laboratory experiments here described every care was taken to avoid any even small contamination of the aluminium by foreign matter of a metallic nature, although the sheets are coated with a film of paraffin oil from the rolling process. It would seem probable that under industrial conditions such contamination is not, or possibly cannot be, entirely avoided, and that the deterioration ascribed to re-melting is in reality due to slight progressive contamination with other materials. In order to ascertain whether in the present series of experiments there had been any appreciable change in composition, chemical analysis was carried out on the material produced after the seventh re-melt in Series 1 and the tenth re-melt in Series 2. The following results were obtained :—

Series 1.

	1st Melt.	7th Melt.	Skimmings.
Iron ...	0·17	0·22	0·16
Silicon ...	0·17	0·16	0·18

Series 2.

	1st Melt.	10th Melt.	Skimmings.
Iron ...	0·77	1·05	1·00
Silicon ...	0·72	0·85	0·72

It will be seen that in Series 1 no appreciable change in composition has occurred, while in Series 2 the iron content has increased to some extent.

PROPOSED TUBE RAILWAYS IN CALCUTTA.—The Office of the High Commissioner in London for India has forwarded to the Department of Overseas Trade copies of a report on the possibilities of a tube railway in Calcutta between the East Indian Railway and the Eastern Bengal Railway, together with a book of plans and a longitudinal section. These documents can be inspected by representatives of United Kingdom firms interested, on application to the department (Room 49), 35, Old Queen-street, London, S.W. 1.

THE DEPARTMENT OF AERONAUTICS AT THE IMPERIAL COLLEGE.—A pamphlet briefly explaining the organisation and objects of the Department of Aeronautics of the Imperial College of Science and Technology has reached us from that institution. The department, it will be remembered, was established in 1920–21 to give effect to the scheme proposed by the Committee on Education and Research in Aeronautics, in whose report the opinion was expressed that the Imperial College should become the central school for advanced study in aeronautical science. The school is mainly a post graduate one, and is divided into two main sections, viz., aeronautical engineering and meteorology and navigation. The complete course normally extends over two years, the first of which is spent at the college and the second at an experimental or research station, or at the National Physical Laboratory. A course of advanced study lasting over a year has, however, been arranged for those who cannot give two years to the complete course, and a syllabus of this course is included in the pamphlet. The director of the department is Sir R. T. Glazebrook, Zaharoff Professor of Aviation, while Sir Napier Shaw is Professor of Meteorology, Mr. L. Bairstow is Professor of Aerodynamics, and Mr. F. T. Hill is lecturer in designs and superintendent of the drawing office. The lecturers for the ensuing session include Mr. V. C. Richmond (airships), Mr. H. E. Wimperis (navigation), and Dr. A. J. Sutton Pippard (strength of structures); a lecturer on engine design is to be appointed.

TRADE WITH ULSTER.—The following letter has been addressed by the President of the Belfast Chamber of Commerce to the principal Chambers of Commerce and railway companies in Great Britain: "Dear Sir,—Merchants in Belfast and District have recently received from manufacturers and merchants in various parts of Great Britain letters to the following effect: 'Owing to the unsettled state of Ireland we are now obliged to make the terms cash with order, &c.'; they have also learned that officials of railway companies in Great Britain, on the pretext of 'the unsettled state of Ireland,' occasionally refuse to accept consignments of merchandise for Belfast and district. It is assumed that such action on the part of manufacturers and merchants and railway officials is due to ignorance of the actual state of things in Northern Ireland generally, and Belfast and district in particular. I, therefore, wish to point out that so far as Belfast and Northern Ireland are concerned, there is no valid excuse for the new impositions in the matter of terms, which unwarrantably reflect upon the credit of one of the thoroughly solvent parts of His Majesty's Empire, or for refusal on the part of carriers to accept consignments in the ordinary way. Business proceeds in Belfast and Northern Ireland as formerly, and the financial stability of the mercantile community remains intact; for instance, Belfast Corporation Stock stands above par; Belfast fine trade bills can be negotiated at the minimum. The facts show that there is no greater risk in carrying merchandise from any part of Great Britain to Belfast and district than is experienced by the carrying companies in the daily conduct of their affairs in any part of Great Britain."

ON THE DIMINUTION OF LAG AT Ar1 THROUGH DEFORMATION.*

By J. H. WHITELEY.

EVIDENCE of lag in the crystallisation of pearlite, particularly in hypo-eutectoid steels, is derived from several considerations. It is found in the well-known fact that, for a given steel, the temperature of the Ar1 transformation is not constant but is lowered as the rate of cooling is increased. Again, since the presence of carbide nuclei within the γ-iron areas induces crystallisation of the carbide and ferrite as globular pearlite at a temperature considerably higher than that at which growth takes place in the absence of such nuclei, lag must clearly occur in the latter case. Further, the growth of lamellar pearlite, when once started, does not occur simultaneously throughout the specimen. The change proceeds gradually, and there is no difficulty in quenching a piece so that it contains areas of both pearlite and martensite intermixed. An example is seen in Fig. 3; the specimen showing this structure was cooled from 900 deg. to 695 deg. C., and held there for half-an-hour before it was quenched. Here, only one γ-iron area has changed to pearlite; if the specimen had been maintained at this temperature, or if it had been allowed to cool extremely slowly, the remaining γ-iron areas would have continued to crystallise almost one at a time. In Fig. 2 the change has progressed much further but is still incomplete.

These facts make it clear that lag occurs at Ar1, which means that ordinary lamellar pearlite is formed from a super-saturated solid solution. In the case of super-saturated liquid solutions it has been found that agitation or stirring of the liquid is sometimes effective in initiating crystallisation and thus reducing lag.† Usually, in determining the recalescence points the specimen is allowed to cool undisturbed, and it therefore appeared of interest, at any rate from a theoretical standpoint, to ascertain whether the temperature and rate of pearlitic growth could be increased through disturbances of structure caused by deformation of the steel when in the metastable condition of supersaturation. In the experiments described below, which were made for this purpose, two methods of deformation were used, namely, hammering and bending.

Description of Apparatus.—A small electrical furnace, A, Fig. 1, containing a silica tube 1 in. internal diameter, wound with nichrome wire, was placed vertically on a block of steel B, which rested upon two supports as shown. A bar of hard chrome steel C, ½ in. square section, was used as an anvil, and between it and the block B there was a thick pad of asbestos board. The thermocouple D passed through a hole drilled in the block, and was so placed that the temperature of the furnace at the surface of the anvil was recorded. A rod of manganese steel E was used to transmit the hammer-blows to the specimen on the anvil. This material was selected chiefly because it is non-magnetic; difficulty in manipulation during the experiment, owing to the magnetisation of the specimen, was thus avoided. The space around the anvil and thermocouple tube was well filled with asbestos fibre.

Experiment 1. *Deformation by Hammering.*—In this experiment the steel used was the same as that which had been employed in an investigation recently recorded on the formation of globular pearlite.‡ It consisted of a piece of ordinary mild steel plate which had been allowed to cool in the centre of a solidifying slag ball; the normal banded structure was thus eliminated and an approximate uniformity in composition obtained. The Ar1 point had previously been found, by quenching specimens, to lie between 685 deg. and 690 deg. C., and Ac1 between 715 deg. and 720 deg. C. Two small sections, differing in shape so as to be easily distinguished, each weighing about 1·0 gramme, were placed on the anvil C, and the rod E placed on the adjacent asbestos packing. The temperature was raised to 900 deg. C. and then lowered in about ten minutes to 695 deg. C. After the pieces had remained at this temperature for 15 minutes, in order to give time for equilibrium conditions to be established, the rod E was carefully placed on one of them and a smart blow given with a hammer. To ensure against the effect of any slight difference in temperature between the end of the rod and the pieces, the rod was also placed on the other, but no blow was given. The positions of the two pieces were then interchanged, this being done by means of a thin rod of silica tube which had previously been placed in the furnace. During the next 10 minutes the temperature was kept at 695 deg. C. and the above procedure repeated, in varying order, about six times, and after a further 5 minutes the specimens were rapidly quenched in water. The deformation made by hammering in this way was found to be comparatively small; the same experiment was done several times, and in no instance was the depth of the piece ($\frac{1}{16}$ in.) reduced more than $\frac{1}{10}$ in.

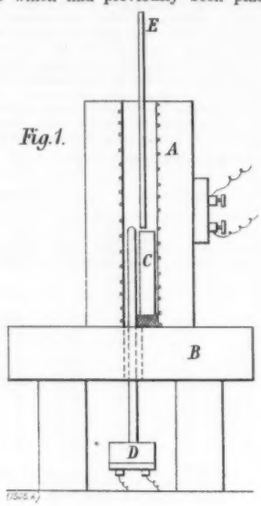


Fig. 1.

The results obtained from the repeated experiments all agreed. They showed unmistakably that lag at Ar1 could be diminished by slight deformation. Examples of the structures produced are given in Figs. 2 and 3, above. Fig. 2 is that of the hammered piece; the dark areas are pearlite, and it is quite clear that the transformation was nearly complete when the piece was quenched. Very few unchanged areas of hardenite are to be seen. In Fig. 4 a typical pearlite crystal in this specimen is shown under a higher magnification; it will be noticed that the deformation has not been sufficient to cause any appreciable "divorce" to occur. Fig. 3 shows the structure of the unhammered piece in the same experiment. Here, only one area of solid solution has changed into pearlite. To have produced at 695 deg. C. the same degree of transformation in this piece as in the hammered piece, a much longer heating would have been necessary. As before stated, the transformation at this temperature was found to take place very slowly in undisturbed specimens. In two instances the pearlite had not even begun to form in the unhammered piece, while in the hammered specimens the change was well on the way to completion. It would appear, therefore, that lag both as regards time and temperature can be diminished by deformation.

Experiment 2. *Deformation by Bending.*—The apparatus shown in Fig. 1 was also used in this experiment. In order to bend the specimens a V-shaped notch ¼ in. deep was cut in the top of the anvil C, and the end of the rod E shaped like a chisel. A strip ½ in. by $\frac{1}{16}$ in. of steel sheet, $\frac{1}{16}$ in. thick, of similar composition to the steel used previously was placed across the notch, heated to 900 deg. C. and cooled to 695 deg. C. When the piece had remained at 695 deg. C. for 15 minutes, the rod was placed upon it so that the end was in line with the notch and two or three light blows were then given with a hammer. The strip was bent in this way through an angle of about 60 deg. After a further 5 minutes at 695 deg. C., the piece was taken out and rapidly quenched. This experiment was also made repeatedly, in each case with the same result. At the bend, pearlite was always present, as shown in Fig. 5, but in the limbs, where the metal had not been distorted, the structure consisted almost entirely of ferrite and martensite. An instance is seen in Fig. 6. A similar, but less pronounced effect, was produced when strips were bent at 700 deg. C.; pearlite was present only at the bends, about one-fourth of the austenite having crystallised. The first results obtained by hammering only were therefore fully corroborated in these bend tests. They show that lag at Ar1 can be appreciably diminished through deformation.

It should be noted that although lag was reduced it was not completely eliminated by the methods of deformation used, for in a previous investigation with the same steel globular pearlite was found to grow between 705 deg. and 708 deg. C., when carbide nuclei were present in the austenite. Possibly, if the metal could be sufficiently distorted, lag in the formation of lamellar pearlite would be equally diminished.

In conclusion, it may also be mentioned that since a certain amount of lag also occurs at the Ar3 point, a few similar experiments were made in order to ascertain whether this supercooling could likewise be reduced by deformation. Strips were heated to 900 deg. C., cooled to temperatures a little below Ac3, and then bent. Here however, the separation of free ferrite from the solid solution did not appear to be acceleratd by the deformation produced in this way.

Summary.—Evidence is given that when steel, in the metastable region at the Ar1 point is worked, lag is markedly diminished.

Fig. 2. Exp. 1. Hammered piece. Etched with picric acid. × 140.

Fig. 3. Exp. 1. Unhammered piece. Etched with picric acid. × 140.

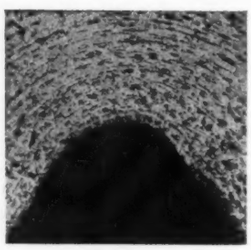


Fig. 5. Exp. 2. Pearlite at bend. Etched with picric acid. × 55.

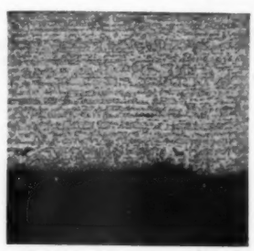


Fig. 6. Exp. 2. Hardenite in limb. Etched with picric acid. × 55.

Fig. 4. Exp. 1. Typical Pearlite in Hammered Piece. Sodium Picrate Stain. × 1050.

BRADFORD ENGINEERING SOCIETY.—The Bradford Engineering Society will open its twenty-fourth session on Monday, October 2, when the President, Mr. C. E. Alsopp, will deliver an address on "The Development of Public Electricity Supply." Altogether some 14 lectures have been arranged for the session, the subjects chosen covering a very wide field and embracing a range of subjects sufficiently great for all members to find subjects of interest to themselves. All responsible for the lectures are drawn from outside Bradford itself, and in many cases the subjects are in the hands of men to whom special information is available. The list of fixtures further includes the annual dinner arranged for January 26, while the session will terminate with the annual general meeting provisionally fixed for March 26. The meetings are held at the Technical College, and Professor G. F. Charnock is hon. secretary.

RUSSIAN MANGANESE ORE FOR GERMANY.—It is reported from Kharkoff that the concession commission in the Ukraine recently examined various applications from foreign firms for concessions, according to *The Iron Age*. One leading foreign firm submitted an offer for the leasing of the iron ore mines at Kholaczevskie, in the basin of the Krivoi-Rog, but the commission refused to grant a concession on the ground that the ore mines can only be leased if blast furnaces are operated. The German Mining Association of Essen—the Berg und Hüttenwerke—is reported to have been more successful. After protracted negotiations with the Ukraine commission in Berlin, the association is said to have arranged for the annual supply of a large quantity of manganese ore in return for the delivery to the Ukraine Mining Association of materials for the working of the mines, including cables, pumps, &c. The German association will only accept the delivery of high-grade ore.

* Paper read at the meeting of the Iron and Steel Institute, York, on Tuesday, September 5, 1922.

† Recently, A. F. Hallimond, in discussing this question of delayed crystallisation, has remarked that for super-saturated solid solutions violent mechanical working may be the analogue of agitation. (ENGINEERING, vol. cxiii, pages 628 and 767).

‡ ENGINEERING, vol. cxiii, pages 628 and 767.